THE JOURNAL OF
Engineering Education

LIBRARY
COLLEGE OF ENGINEERING
DUKE UNIVERSITY

March, 1954 Vol. 44, No. 7

Contents for March

Do You Know 351
Annual Meeting, University of Illinois 354
Liberal Education in Professional Curricula ..... *V. M. Hancher* 356
It is Time for Laymen to Come In ..... *J. F. Calvert* 362
Proposed Amendment on Membership Dues 370
Summer Schools and Summer Institutes, 1954 372
Needs for Basic Research in Engineering Science ..... *R. A. Morgen* 375
Role of Physics in Engineering Education ..... *R. J. Seeger* 385
Professional Collective Bargaining ..... *T. H. Evans* 389
Teaching Tips (A New Feature) 392
The Final Course ..... *A. Boyajian* 394
Graduate Program in Engineering ..... *W. E. Howland and G. A. Hawkins* 397
Physics for the Civil Engineer ..... *N. W. Dougherty* 401
Books on Mathematics for Engineers ..... *A. F. Puchstein* 404
Timely Tips 407
Minutes of the Executive Board Meeting 409
Teaching Positions Available 412
Section Meetings—413 New Members—414
College Notes—388, 391, 418 In the News—416

The American Society for Engineering Education

2 outstanding texts

Grinter

ENGINEERING MECHANICS

For both the sophomore course in statics and the junior course in dynamics, this text presents mechanics in logical thought-sequence, solving special cases and numerical examples directly from a few basic laws. It treats statics before dynamics, divides space and emphasis equally between the two subjects, and begins with a section on the history of mechanics.

1953 *408 pp.* *$5.75*

Woods & DeGarmo

Introduction to

ENGINEERING ECONOMY

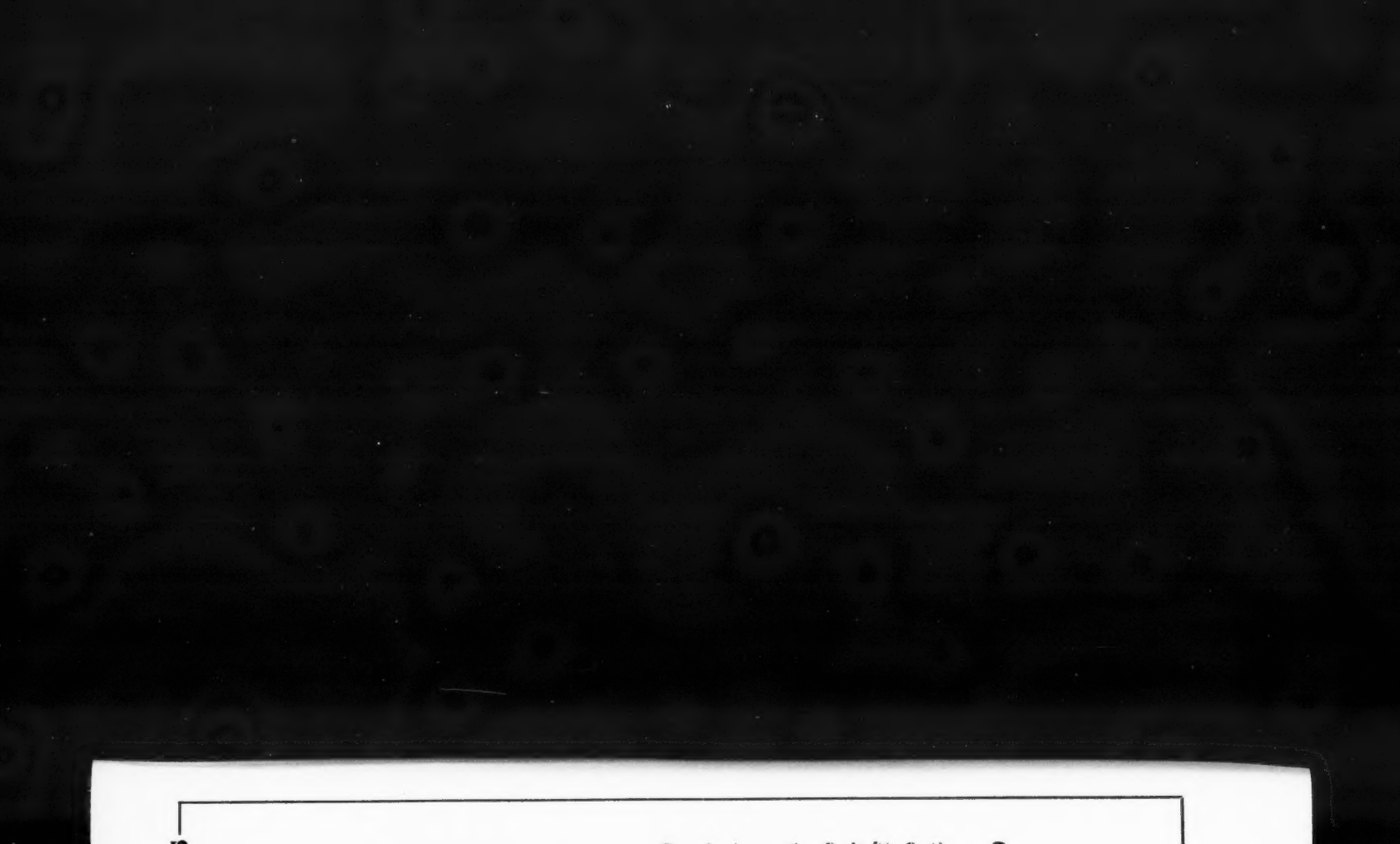
Revised Edition

Bringing completely up-to-date this full coverage of the economic problems of engineering, the authors cover such topics as investment—its purposes and methods of determining its advisability; production problems; the use of statistical methods; and quality control as it relates to the economy of production.

1953 *519 pp.* *$6.00*

The Macmillan Company

60 FIFTH AVENUE, NEW YORK 11, N.Y.



International

MACHINE DESIGN **New 3d Edition**

VLADIMIR L. MALEEV, Professor Emeritus of Mechanical Engineering, Oklahoma A. & M. College, and JAMES B. HARTMAN, Department of Mechanical Engineering, Lehigh University

The primary objectives in the revision of this outstanding text have been (1) to improve the teachability of the book and (2) to bring it up to date. The book (completely reset) has been carefully rewritten, and considerable new material on many topics has been introduced. *Ready in May.*

ENGINEERING THERMODYNAMICS **New 2d Edition**

JESSE S. DOOLITTLE and ALEXANDER H. ZERBAN, Departments of Mechanical Engineering, North Carolina State College and The Pennsylvania State University

A book that presents thermodynamics in a simple, straightforward manner. In the new edition the textmatter has been carefully rewritten in many sections, and over 800 problems are included. *Ready in June.*

ELEMENTARY SURVEYING

WARREN C. TAYLOR, formerly Chairman of the Department of Civil Engineering, Union College

An outstanding text for a brief course in surveying. The treatment is as concise as possible without the sacrifice of essentials necessary for a complete understanding of the subject. Especially well-suited for service courses. *Second Edition, 1949, 256 pages. $2.75.*

SURVEYOR'S FIELD-NOTE FORMS

CLARENCE E. BARDSLEY, United States Bureau of Standards, and ERNEST W. CARLTON, Department of Civil Engineering, Missouri School of Mines and Metallurgy

An invaluable aid in teaching students proper methods and practices of recording field data, with emphasis placed on the development of the habit of keeping neat, legible, and systematic notes. Can be used with any general surveying text. *Third edition, 1952, 127 pages. $1.75.*

INTERNATIONAL TEXTBOOK COMPANY
Scranton 9, Pennsylvania

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

OFFICERS FOR 1953–54

President: L. E. GRINTER, Dean of Graduate School, University of Florida, Gainesville, Florida.

Vice President (instructional division activities): W. C. WHITE, Vice President, Northeastern University, Boston, Mass.

Vice President (general and regionsl activities): B. R. TEARE, JR., Dean of Engineering and Science, Carnegie Institute of Technology, Pittsburgh 13, Pa.

Vice President (Engineering College Administrative Council): W. L. EVERITT, Dean of Engineering, University of Illinois, Urbana, Ill.

Vice President (Engineering College Research Council): E. A. WALKER, Dean of Engineering, Pennsylvania State College, State College, Pa.

Treasurer: G. W. FARNHAM, The Ronald Press Company .....New York 10, N. Y.

Secretary: ARTHUR B. BRONWELL.....Northwestern University, Evanston, Ill.

Editor of the Journal and Assistant Secretary: C. E. WATSON, Northwestern University, Evanston, Ill.

Office Secretaries: MARION STROHM, MARIAN LONG, and KATHRYN CRANFORD Northwestern University

Junior Past Presidents: W. R. WOOLRICH, S. C. HOLLISTER, F. M. DAWSON

REPRESENTATIVES ON THE GENERAL COUNCIL

REPRESENTING DIVISIONS

Aeronautical—G. MURPHY
Agricultural Engineering—O. C. FRENCH
Architectural—W. W. DORNBERGER
Chemical Engineering—R. M. BOARTS
Civil Engineering—E. H. GAYLORD
Cooperative Engineering—H. C. MESSINGER
Educational Methods—H. R. BEATTY
Electrical Engineering—H. E. HARTIG
Engineering Drawing—R. S. PAFFENBARGER
English—C. A. BROWN
Evening Engineering Education—R. W. VAN HOUTEN
Graduate Studies—E. WEBER
Humanistic-Social—J. W. SHIRLEY
Industrial Engineering—J. M. APPLE
Mathematics—H. K. JUSTICE
Mechanical Engineering—H. KUENZEL
Mechanics—W. L. COLLINS
Mineral Engineering—C. WILSON
Physics—G. P. BREWINGTON
Relations with Industry—G. D. LOBINGIER
Technical Institutes—H. P. RODES

REPRESENTING SECTIONS

Allegheny—E. B. STAVELY
Illinois-Indiana—E. F. OBERT
Kansas-Nebraska—M. A. DURLAND
Michigan—W. P. GODFREY
Middle Atlantic—T. SAVILLE
Missouri—L. E. STOUT
National Capital—H. H. ARMSBY
New England—G. A. MARSTON
North Midwest—K. F. WENDT
Ohio—N. D. THOMAS
Pacific Northwest—E. R. WILCOX
Pacific Southwest—R. E. VIVIAN
Rocky Mountain—E. J. LINDAHL
Southeastern—R. L. SUMWALT
Southwestern—N. F. RODE
Upper New York—G. K. PALSGROVE

Society Headquarters: Northwestern University, Evanston, Illinois

ANNUAL MEETING—UNIVERSITY OF ILLINOIS
Urbana, Ill. June 14–18, 1954

Published monthly (except during July and August) at Prince and Lemon Sts., Lancaster, Pa., by the American Society for Engineering Education under the Supervision of the Publication Committee: A. B. Bronwell, Chairman, Northwestern University, W. R. Woolrich, R. F. Bitner, L. E. Grinter, C. E. Watson, Editor. Entered as second class matter, October 17, 1912, at the Post Office at Lancaster, Pa., under the act of August 12, 1912. Subscription Price, $6.00 per year; Single Copies, $1.25.

2 spring publications

Ware & Town
ELECTRICAL TRANSIENTS

A text which enables the undergraduate student to obtain a firm grasp of the principles involved in the action of electrical circuits under transient conditions and gives him a facility in the use of the mathematical tools required for the analysis of such circuits.

ready this spring

Pare, Loving & Hill
DESCRIPTIVE GEOMETRY WORKSHEETS

Series B

Covering the drafting and layout work of standard descriptive geometry courses, this workbook supplements the DESCRIPTIVE GEOMETRY WORKSHEETS published in 1950 by providing a *completely different set* of descriptive geometry problems, thus enabling the teacher to introduce different sets of problems in alternate years or semesters. Adequate space is provided for the completion of partial layout problems.

ready this spring

The Macmillan Company
60 FIFTH AVENUE, NEW YORK 11

Recent and Forthcoming

HANDBOOK of STANDARD TIME DATA

For Machine Shops

Arthur A. Hadden, *Late President;* **and Victor K. Genger,** *Vice-President, McClure, Hadden & Ortman, Inc., Management Engineers*

Just out—First one-volume source for all tested, detailed standard data needed for establishing machine shop time values. Provides separate tables for each common type of machine tool. Specifications for manual operations recognize such variables as weight of piece, transportation, etc. Recommendations for machining and tables for machine elements cover type of equipment, amount of material to be removed, etc. *87 forms, tables, 474 pp.*

THE FLOOD CONTROL CONTROVERSY

Big Dams, Little Dams, and Land Management

Luna B. Leopold, *United States Geological Survey;* **and Thomas Maddock, Jr.,** *United States Bureau of Reclamation*

Ready in May—Clarifies both the technical problems and economic and political issues in flood control. Explains the nature of river floods and measures for their control. Evaluates present control methods, examines hydrologic considerations, and weighs the effectiveness of current and proposed flood protection plans. Foreword by Fairfield Osborn. A Conservation Foundation Study. *31 ills., 316 pp.*

PRINCIPLES of INDUSTRIAL PSYCHOLOGY

Thomas Arthur Ryan *and* **Patricia Cain Smith**
—both of Cornell University

Ready this Spring—Sets forth accepted facts of industrial psychology, delineates its subject matter, describes its methods, and recommends procedures which may be applied to a wide variety of problems in industry. Critically examines this material, stressing the need for general unifying principles and theories. *58 ills., 600 pp.*

A GUIDE TO TECHNICAL WRITING—*2nd Edition*

W. George Crouch, *University of Pittsburgh;* **and Robert L. Zetler,** *Pennsylvania College for Women*

A Spring publication—Well suited to the needs of undergraduates in engineering and others who write on technical subjects. Includes new illustrative material, expanded discussion of the report, analysis of examples of technical exposition. New edition incorporates the suggestions of instructors who used early edition. *51 ills., 480 pp.*

THE DYNAMICS AND THERMODYNAMICS of COMPRESSIBLE FLUID FLOW

Ascher H. Shapiro, *Massachusetts Institute of Technology*

New—Complete single-source reference work offers a comprehensive and unified treatment of virtually all aspects of compressible fluid mechanics. Discussions based on a combination of clear physical reasoning, theoretical treatment, and experimental research. All important results reduced to chart form. Vol. I—Ready Now—*635 ills., 647 pp.* Vol. II—Ready Spring —*560 ills., 600 pp.*

THE RONALD PRESS COMPANY

Books from RONALD

STRUCTURAL DESIGN in REINFORCED CONCRETE

Clifford D. Williams, *Patchen and Zimmerman, Engineers;* **and Charles E. Cutts,** *University of Florida*

Ready in April—Emphasizes general principles of design without detailed analyses of their application to complex structures. Throughout, formulas are derived and used continuously; all problems developed from strength of materials concepts. Special sections on construction methods, pre-stressed concrete, design for ultimate stress, design of circular tanks, compression and bending in two directions. *218 ills., 310 pp.*

ELEMENTS of STRUCTURAL ENGINEERING

Ernest C. Harris, *Fenn College*

Ready this Spring—Shows application of principles of structural engineering in terms of examples and problems faced by non-civil engineers. Engineering principles, inherent in original design of buildings, are highlighted by analyzing effect of new electrical and mechanical equipment on safety. Includes tables of section properties, load data, symbols, and design specifications for steel and reinforced concrete. *337 ills., 552 pp.*

ELECTRIC POWER TRANSMISSION

The Power System in the Steady State

John Zaborszky *and* **Joseph W. Rittenhouse**
—both of the University of Missouri

A Spring publication—Offers broad coverage of the steady operation of transmission lines and power systems, as well as the methods for studying such operations. Enriched throughout with discussions of recent technological advancement. Numerical examples are used extensively to provide better insight into the workings of a power system. Incorporates original research. *368 ills., 690 pp.*

STATICALLY INDETERMINATE STRUCTURES

Paul Andersen, *University of Minnesota*

This up-to-date book for courses in statically indeterminate structures directly associates structural analysis with structural design. Numerical applications of actual design problems are an integral part of the work which includes an entire chapter on typical design problems. Emphasizes deflections, their importance in understanding the behavior of structures under load. *370 ills., 318 pp.*

HIGHWAY ENGINEERING

L. J. Ritter, Jr., *University of Florida*
R. J. Paquette, *Georgia Institute of Technology*

For modern courses in highway engineering and civil engineering. This textbook reflects the far-reaching changes of the past two decades and fully covers planning, design, preparation of contracts, construction work, and maintenance. Stresses the use of modern equipment, highway administration, economics and financing. *260 ills., 721 pp.*

15 East 26th Street, New York 10, N.Y.

ENGINEERING BOOKS

CONTROL SYSTEM DYNAMICS

By WALTER R. EVANS, Group Leader, Systems Group, Autocontrol Section, Electromechanical Engineering Department, North American Aviation, Inc., Downer, California. In press

An exposition of the "Root Locus Method" invented and developed by the author, this new volume demonstrates the techniques for determining the response of linear control systems. The root locus, a tool to factor an algebraic polynomial is useful in analyzing the pertinent differential equations in feedback control systems. Developing from the simple to the complex, each solution establishes a concept which permits a simpler technique to be applied to the next, more complicated, problem.

PROBABILITY AND INFORMATION THEORY, WITH APPLICATIONS TO RADAR

By P. M. WOODWARD, Principal Scientific Officer, Telecommunications Research Establishment, Ministry of Supply, Malvern, England. Electronics and Waves. *A Series of Monographs.* 138 pages, $4.50

This book explains in easy stages how the theory of probability applies to electronics, communication, and particularly radar. It was prepared for the reader with no highly-advanced mathematical knowledge who is interested in linking his practical "intuition" with precise mathematical theory.

FOUR PLACE TABLES OF TRANSCENDENTAL FUNCTIONS

By W. FLÜGGE, Stanford University. 136 pages, $5.00

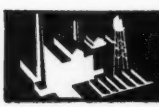
Published in cooperation with the Pergamon Press in England, these tables are for use in calculations for which the order of accuracy afforded by the slide rule is sufficient. Containing formulas necessary to handle the functions, the tables deal with trigonometric, hyperbolic, exponential, and logarithmic functions, certain of the Bessel functions, and elliptic integrals, the Fresnel integrals, the error function, the sine-, cosine-, and exponential-integral functions, and the gamma function. Values in all tables are given to four digits, and except for the Fresnal integrals, are in error by no more than one unit in the fourth digit. The numerical tables are supplemented by definitions and lists of relevant formulas which serve, in particular, to permit the evaluation of each function for arguments outside the tabulated range.

THE COMPLEAT STRATEGYST

By JOHN D. WILLIAMS, RAND Corporation. In press

In a light, humorous, and easily readable style, this book covers an elementary explanation to the theory of games and methods for its application to problems involving conflict situations which resemble games. The theory is presented without use of anything higher than secondary school arithmetic, and worked out examples of its application to situations ranging from checker and card games to business problems and military strategy are included.

Send for copi ***on app***



McGRAW - HILL
330 West 42nd Street

from McGRAW-HILL

DISLOCATIONS IN CRYSTALS

By W. T. READ, JR., Bell Telephone Laboratories, Inc. *International Series in Pure and Applied Physics.* 219 pages, $5.00

A specialized text and reference in a very important phase of solid state physics, this volume is written for physical metallurgists and physicists interested in the phenomena associated with imperfections in the crystal structure. It explains what dislocations are, what they do, and how they produce effects which one can study experimentally. Emphasis is upon a systematic introductory account of what is definitely known about dislocations.

NON-FERROUS FOUNDRY METALLURGY: The Science of Melting and Casting Non-Ferrous Metals and Alloys

By A. J. MURPHY, University of Birmingham, England. In press

Here is a symposium published in cooperation with the Pergamon Press in England which sets forth the scientific principles underlying fundamentally good practices in the foundry industry. The book replaces, with scientific principles, the empirical procedures and *ad hoc* solutions of recurring problems which have lingered longer in this industry than in other branches of applied metallurgy.

PHYSICS AND APPLICATION OF SECONDARY ELECTRON EMISSION

By H. BRUINING, Philips Research Laboratories, Eindhoven, Netherlands. 170 pages, $5.00

The book treats the phenomenon of secondary electron emission, the emission of electrons by solid substances, resulting from the impact of electrons. Since electron multiplication can be obtained, the phenomenon is most important from a technical view: the applications are of considerable significance in electron tubes for radio and television. The book is of value to communication engineers and physicists in universities and in industrial research.

RELAXATION METHODS

By D. N. DE G. ALLEN, Imperial College of Science and Technology in the University of London. 274 pages, $7.50

Shows the beginner how to use the relaxation method to solve various mathematical problems which arise in engineering science and applied physics. Here is the clearest and most valuable exposition of relaxation methods to date. Emphasis is placed on explaining in detail the arithmetical processes and techniques which become automatic and instinctive to the successful computer.

for copie ***on approval***

BOOK COMPANY
New York 36, N. Y.

NEW McGraw-Hill Books

PRACTICAL PLANT LAYOUT

By RICHARD MUTHER, Management Engineer, The Vendo Company and formerly Massachusetts Institute of Technology. In press

Here is a practical, hot-to-do-it guide to the elements of good plant layout and the specific procedures of planning sound layouts. In four parts, the book analyzes the fundamentals of the layout problem and shows the eight factors involved, then gives clear, complete directions for the practical steps of collecting data, planning the layout, and installing it. Detailed examples, case illustrations, and specific techniques are given to make the book helpful to the production man without experience as well as to the man with it, and pointers are given on management's part in achieving good plant layout.

INTRODUCTION TO INDUSTRIAL MANAGEMENT. New fourth edition

By FRANKLIN E. FOLTS, Harvard University. In press

In this thorough revision of a successful text the underlying goals remain unchanged. The primary object has been to deal with business and economic conditions as they exist in industry, with theory presented only as background for the solution of a practical situation. Text material is centered around concrete business situations, the object of the presentation being to force the student to think in terms of cases and problems taken from actual business life.

TIMESTUDY FOR COST CONTROL. New third edition

By PHIL CARROLL, Professional Engineer. In press

A simple, practical manual for timestudy and control based on predetermined standards. In approach and treatment the work is especially suited to the needs of medium and small sized plants where motion study by the motion picture method is too costly and time-consuming. The book shows how to select men for timestudy work and gives step-by-step procedures right through from how and where to start, to the application of the data in production control, including such topics as analyzing timestudy results, building standard data and data work sheets, getting incentive performance, and maintaining correctness in standards.

PUBLICITY FOR PRESTIGE AND PROFIT

By HOWARD STEPHENSON and WESLEY FISKE PRATZNER. 304 pages, $4.50

Here is a survey and working manual of all phases of public relations, emphasizing the publicity point of view, and describing in detail the techniques of building prestige through publicity. Easy to read, the book uses case examples and gives sources of publicity material and tells how to prepare it for all media.

Send for copies on approval

McGRAW-HILL BOOK COMPANY, Inc.
330 West 42nd Street New York 36, N. Y.

Prentice-Hall
COLLEGE TEXTS

COMING SOON!

EXPERIMENTAL STRESS ANALYSIS

by MARK B. MOORE, *Rutgers University*

OUTSTANDING FEATURES:

- *This book is not a handbook of stress analysis methods, but is designed to stimulate original thinking processes by the individual student.*
- The use of mathematics is kept to a minimum, thereby making it possible to use the text effectively at almost any undergraduate level.
- The use of laboratory experiments is coordinated with the theoretical work in the classroom.

Approx. 182 pages · 5⅝" x 8⅜"

CONSTRUCTION METHODS AND MACHINERY

by F. H. KELLOGG, *Dean of Engineering, U. of Miss., consultant for TVA, formerly consulting engineer of dams and buildings for the governments of Punjab and Bombay*

This work is based on the author's combination of experience in construction and experience in teaching; it ties together the fundamentals studied separately in a Civil Engineering curriculum and presents a quantitative treatment of their applications to the construction industry.

It shows how the various fundamentals taught in Engineering schools fit in practice. The book presents construction methods and machinery as an analogy of production planning and control in the Industrial Engineering phase of Mechanical Engineering. It includes quantitative discussions of construction operations most frequently encountered in the construction industry.

415 pages · 5⅝" x 8⅜" · Published January 1954

DESIGN IN STRUCTURAL STEEL

by JOHN E. LOTHERS, *Oklahoma A & M College*

How to apply the latest specifications in building and bridge construction and how to use the most recent methods of analysis and design is the subject of this new text.

It features a unique "project" method of presentation. Using this procedure, several chapters begin by setting up the data for an illustrative problem. As the theory upon which the illustrative problem is based unfolds, its application is demonstrated in a series of examples which refer back to the illustrative problem.

Chapter 8, for example, uses this "project" method to show the analysis and design of an industrial building bent for wind, snow and crane loads, including the complete analysis of a crane runway girder for vertical, lateral, and longitudinal moving loads.

454 pages · 6" x 9" · November 1953

These texts are in the Prentice-Hall Civil Engineering and Engineering Mechanics Series, N. M. Newmark, *Editor*.

Send for Your Copies Today

PRENTICE-HALL, INC. 70 FIFTH AVENUE, NEW YORK 11

WILEY BOOKS

ANALYTIC GEOMETRY, Second Edition

By EDWARD S. SMITH, MEYER SALKOVER, *and* HOWARD K. JUSTICE, *all of the University of Cincinnati.* Here is a text designed to develop in the beginning student the reasoning processes of analytic geometry. The revision offers a completely new set of problems and many features that add to the value of this well-known text. Among the changes are: a new article on analytical proofs of geometric theorems; clarification of some sections; and a 4-place table of trigonometric functions with angles in radians and degrees. ***1954. Approx. 310 pages. Probably $4.50***

APPLIED ELECTRONICS, Second Edition

By TRUMAN S. GRAY, *Massachusetts Institute of Technology.* The aim in this revision has been to make the text even clearer for classroom work; to bring the coverage up to date; and to include new developments such as the transistor and its applications. The emphasis is on clarity and reasoning and the book provides all the links which the experienced engineer takes for granted but which are often easily overlooked by the student. ***1954. Co-published with the Technology Press, M.I.T. Principles of Electrical Engineering Series. 882 pages. Illus. $9.00***

ELEMENTARY FLUID MECHANICS, Third Edition

By JOHN K. VENNARD, *Stanford University.* Improved organization and fresh introductory material on one dimensional fluid flow make the new edition even more teachable than earlier issues. ***1954. 401 pages. Prob. $5.50.***

MECHANICS of MATERIALS, Third Edition

By PHILIP GUSTAVE LAURSON *and* WILLIAM JUNKIN COX, *both of Yale University.* Providing a clear understanding of the fundamentals on which machine and structural design are based the material in the new edition has been reorganized and largely rewritten. ***1954. Approx. 419 pages. Prob. $5.75***

Send today for copies on approval

See pages 11 and 12 for news of other Wiley books

JOHN WILEY & SONS, Inc. 440-4th Ave., New York 16, N.Y.

WILEY BOOKS

ENGINEERING CONTRACTS and SPECIFICATIONS

Third Edition

By ROBERT W. ABBETT, *Knappen-Tippetts-Abbett-McCarthy, Engineers.* The new edition of this famous work retains its emphasis on *how* to write contracts and specifications rather than on *what* to write. In consequence it provides the student with a permanent guide to the administration of construction work which is not affected by changing details of practice. The book is expanded by about 25% to cover new material on legal principles, cost plus fixed fee contracts, insurance, bonding, and specification writing. ***1954. Approx. 428 pages. Probably $6.00.***

LINEAR TRANSIENT ANALYSIS

Volume I: Lumped-Parameter Two-Terminal Networks

By ERNST WEBER, *Polytechnic Institute of Brooklyn.* Unlike the general run of texts in this field, Professor Weber's book gives equal consideration to *all* methods of transient analysis. It reviews the classical method, gives a full account of the professional method, and treats the Laplace transform method as well as the Fourier spectrum analysis. The fundamental exposition of these methods makes the book particularly suitable for first graduate courses. ***1954. Approx. 374 pages. Probably $7.00.***

AIRPLANE STRUCTURES, Volume I

Fourth Edition

By ALFRED S. NILES, *Stanford University, and the late* JOSEPH S. NEWELL. The full revision of this standard text covers recent developments and provides a solid foundation of theory on all aspects of airplane structural design. The coverage is broad enough to include fundamental or widely used procedures that should be mastered as a preparation for either more advanced study or work. The text includes numerous problems which effectively buttress the explanations, and there are useful bibliographies and references. ***1954. Approx. 610 pages. Probably $7.00.***

Send today for copies on approval

See pages 10 and 12 for news of other Wiley books

JOHN WILEY & SONS, Inc. 440-4th Ave., New York 16, N.Y.

WILEY BOOKS

Integrates graphics with other subjects in the curriculum . . .

GRAPHICS in ENGINEERING and SCIENCE

By A. S. LEVENS, *University of California*

Now ready for your classes is a *college-level* text that fires student enthusiasm by providing a new approach to the understanding and use of graphics in the solution of innumerable problems in science and engineering. The book is in three parts covering orthogonal projection, technical drawing practice, and graphical practice and applications. It provides material enabling the student to integrate these topics with other subjects in the curriculum such as mathematics, mechanics, and strength of materials. Clear explanations and carefully selected examples show the most effective combination of these elements in research, development, and design. Two companion workbooks cover a full year's course. ***1954. Approx. 606 pages. Probably $6.00.***

ELEMENTS of MECHANISM

By VENTON L. DOUGHTIE, *University of Texas, and* WALTER H. JAMES, *Massachusetts Institute of Technology.* This is a modern and completely up-to-date version of Peter Schwamb's famous textbook. All the essential elements used in the study and design of machines are covered, with emphasis on fundamental principles. ***1954. Approx. 426 pages. Probably $6.00.***

WIND TUNNEL TESTING

Second Edition

By ALAN POPE, *formerly of Georgia Institute of Technology.* A new edition of this standard text, revised and expanded to cover the most recent developments in nearsonic, transonic, supersonic, and hypersonic wind-tunnel testing, as well as low-speed helicopter rotor testing. In addition to the new text material there are many new illustrations and problems. ***1954. Approx. 525 pages. Probably $8.50.***

Send today for copies on approval

See pages 10 and 11 for news of other Wiley books

JOHN WILEY & SONS, Inc. 440-4th Ave., New York 16, N.Y.

Do You Know—

► A grant of $10,000 has been received from the General Electric Company to assist the ASEE in the completion of the project Evaluation of Engineering Education. The Committee met in Atlanta, Georgia, February 18–20 to start preparation of the final report, based upon recommendations from some 118 institutional committees which have worked with the Society Committee in this undertaking. It is expected that the Committee will meet once more in order to complete its work prior to the Annual Meeting in June.

► The National Science Foundation has authorized grants totaling $15,700 for the ASEE sponsored Summer Institutes. The purpose of the Summer Institute program is to expedite the introduction into engineering education of new fundamental concepts in rapidly developing fields of science and technology which hold great promise for the future of engineering. These Summer Institutes will clarify fundamental concepts, assess material as to its importance in engineering education, and seek a logical, orderly pattern for teaching purposes. Each Summer Institute symposium will be preceded by a work conference of leading authorities in the field, representing the divergent viewpoints of the research engineer, the scientist and the educator.

Two Summer Institutes will be held during the Summer of 1954. One will be in the broad field of Solid State Physics and the other in Nuclear Science. The working panel on the Solid State Physics Conference will meet at the University of Illinois, and the open conference will be held at Carnegie Institute, June 21–25, 1954. The working panel for the Nuclear Physics Conference will be at Columbia University and the open conference will be held at Northwestern University, September 7–11, 1954. Please note that advance registration is required at both of the open conferences. Attendance will be limited to 100 people. Announcement of these Summer Institutes appears elsewhere in this issue of the Journal.

► The Society will sponsor six Summer Schools this year, the largest number in its history. Most of these will be held either prior to or immediately after the Annual Meeting at the University of Illinois. An announcement of the Summer Schools and who to write to for information can be found elsewhere in this issue of the Journal. If you plan to attend, please apply early since the attendance at some of these Summer Schools will be limited.

► The Fifth Annual College-Industry Conference, sponsored by the ASEE Division of Relations With Industry, was held in Detroit, January 15–16, in cooperation with the Engineering Society of Detroit and a number of Michigan colleges. Over 350 industrial leaders and educators heard an interesting exposition of the ECPD's program "The First Five Years of Professional Development." This program, which is in the pilot stage at Cincinnati under the direction of Professor Wandmacher, is working with industry and engineering colleges in developing educational programs for the young engineering graduate after he gets into industry. Engineering graduates, embarking upon a new career, after experiencing the unlimited horizons of a

college education, often find the conventionality and the restraining influences of industry severe deterrents to their ambitions and hopes. At this stage in life, the continuing educational programs can serve to bolster the individual's professional growth and improve his outlook on life.

Many thanks to John Gammell, Dean Freund, Don Hunt, and others at the University of Detroit, as well as Guile Graham of the Engineering Society of Detroit for the excellent job in planning and staging this conference.

► May we call your attention to the proposed amendment to By-Law IV on dues of members, printed in this issue of the *Journal*. Ballots will be mailed to the Society membership toward the end of April.

► A technicality in the regulations relating to discharge of draftees from military service might prove helpful to engineering colleges which are considering hiring draftees for teaching or research. If the individual can show a contract for his services, he can get a discharge three months early (after 17 months of service).

► The new President of EJC is our ASEE representative, Dean Thorndike Saville. The Secretary of ASEE will serve as EJC's Chairman of the Committee on Society Secretaries.

► The Annual Meeting this year is shaping up to be one of the most outstanding events in the history of ASEE. One of the General Sessions will be devoted largely to a panel report on Evaluation of Engineering Education, followed by discussion from the floor.

► The ECRC is programing an interesting General Session dealing with "Portraits in Creativity." This will include 3 or 4 leading scientists and engineers who have made substantial contributions in creative thought. They will discuss some of the insights into creative thought processes. Engineering colleges for the most part have emphasized analytical type of thinking. We know very little about what is involved in creative thinking or why some individuals have exceptional creative abilities, while others are completely lacking in this trait.

► The ECAC is preparing an interesting General Session dealing with "Recognition and Incentives for Good Teaching," in cooperation with the Committee on Recognition and Incentives for Good Teaching, the Educational Methods Division, and the Young Engineering Teachers Committee of the Society.

► On Monday afternoon, a session of interest to all Society members will deal with reports on major Society projects. This will include brief reports and discussions on Ethics, the Summer Institute program, the new Humanistic-Social Research Project, Engineering Manpower, Technical Institutes, Teaching Salaries, and other important committee projects.

► In previous issues, we have been giving you snapshot glimpses of a few of the outstanding items in the Annual Meeting program. Here are more which came in as this issue was going off to press.

► The Educational Methods Division and Graduate Studies Division are pooling forces in a conference dealing with the "Integration of Graduate and Undergraduate Instruction" and also another phase of this problem, "Graduate Studies for Engineering Teachers." The Educational Methods Division will also have a conference on "Educational Research and Evaluation of Teaching." The Educational Methods Division and the Mechanical Engineering Division are combining in a program dealing with "Integrating the Science and Art of Engineering and Creative Design."

► Mechanical Engineering has an intriguing paper by Dean Tupper of Toronto entitled "The Masses, Classes, and

Education." They also have a conference with papers on Ethical Relations Between Students and Instructors as well as What the College Expects of the Young Instructor.

► The ECRC and Relations with Industry Division are holding a Joint Conference dealing with "Industrial Sponsorship of Research," looking forward to expanding industrial research as a means of counteracting the decline in government research.

► From Engineering Drawing comes the interesting information of programs dealing with "Fundamentals, What Are They?," "Graphics in an Expanding Scientific Age," and "Analytic Graphics and Engineering Problem Solving," and a dinner talk on "The Past and the Future" by Professor Northrup.

► Chemical Engineering promises an interesting discussion program on "Chemical Engineering Economics" as well as another on "Improvement of Educational Standards in Secondary Schools."

► A number of Divisions are meeting with the Physics Division on Tuesday afternoon to thrash out the subject of "Physics in Engineering Education." This will include the introduction of modern Physics at appropriate places in the advanced engineering curriculum and the problems of establishing a more satisfactory integration of Physics and engineering at the Sophomore level.

► The Electrical Engineering Division has a conference on "The Problems of Training in the Use of Computing Equipment" and a Summer School on "The Elements of Design of Digital Control Circuits," featuring a team of experts from the Bell Telephone Laboratory. The Electrical Engineering Division also plans to hold several conferences on "The Professional Scientific and Professional General Curricula in Power and Electronics."

► The Mathematics Division will hold conferences on "The Problems of Training in the Use of Computing Equipment," "Mathematics as a Sister Science," "The Teaching of Mathematics in Engineering Schools," "The Place of Mathematical Statistics in the Engineering Curriculum."

► The foregoing is a synopsis of a few of about 100 conference titles. In each of these conferences there are many interesting papers which you will want to hear. We will send you a Preliminary Program of the Annual Meeting and registration forms about the end of April. You will want to mark your calender now to attend the Annual Meeting at the University of Illinois, June 14–18.

► We have a number of other lively projects coming to the forefront which we will tell you about in the April and May issues of the *Journal*. Watch this column.

► We'll see you at the Annual Meeting.

ARTHUR BRONWELL, *Secretary*

Annual Meeting, University of Illinois
June 14-18, 1954

An expansive view over Illinois plains will herald for ASEE members the nearness of the host institution for this year's Annual Meeting. Coming closer into the north-central part of the state, towering elm trees are the distinguishing mark of the twin cities of Urbana and Champaign in which is located the main campus of the University of Illinois.

Founded in 1868 as one of a group of colleges partially supported by the Federal Government under the "Land-Grant College Act," the University of Illinois began its history with three faculty members and fifty students. Today on its three campuses, it has a total enrollment of more than 23,000 and a teaching staff of 3,000.

The center of its program, and its administrative offices, are on the main campus at Urbana. Here are fourteen colleges and schools offering 3,000 different courses to nearly 16,000 students. On this campus, the University of Illinois probably has more full-time students in residence than any other educational institution in the country.

The University's Undergraduate Division in Chicago is located on Navy Pier. This Division offers the first two years of college work analagous to that given on the main campus in engineering and architecture, in liberal arts and sciences, and in commerce and business administration. The engineering staff at Navy Pier will join those at Urbana in serving as hosts during the Annual Meeting.

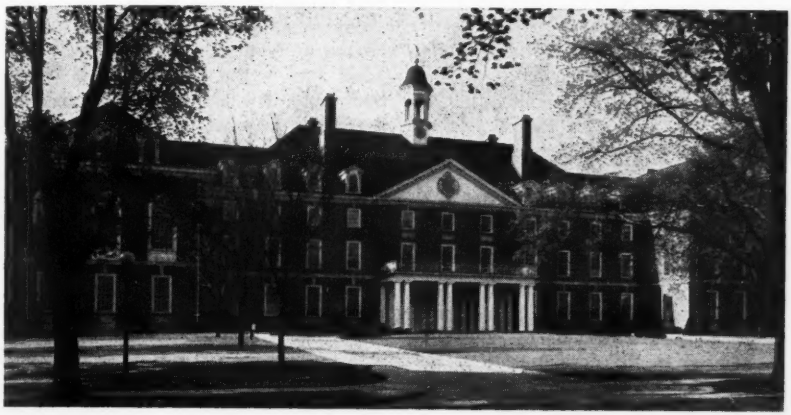
Chicago is also the home of the University's professional units which include the Colleges of Medicine, Dentistry and Pharmacy, and the School of Nursing.

Frequently known as the "front door" of the campus for visitors and the "community center" for students and staff, the Illini Union Building will likewise be the center and main headquarters for the meeting of the ASEE June 13–19. This spacious colonial-style building includes lounges, reading rooms, dining rooms, cafeteria, game rooms and ballroom. Guests may be interested, as well, in many of the approximately ninety-four structures comprising the Urbana-Champaign campus. However, second to the Illini Union, the most prominent building for ASEE members will probably be Gregory Hall. Since, like the Union, Gregory Hall is equipped with air conditioning, most of the main meeting rooms will be located in this building, which regularly houses the Colleges of Education and Journalism. The newest residence hall for women at the University of Illinois, Lincoln Avenue Residence, will be assigned to the ASEE and will provide housing for many of its members, particularly those who bring their families.

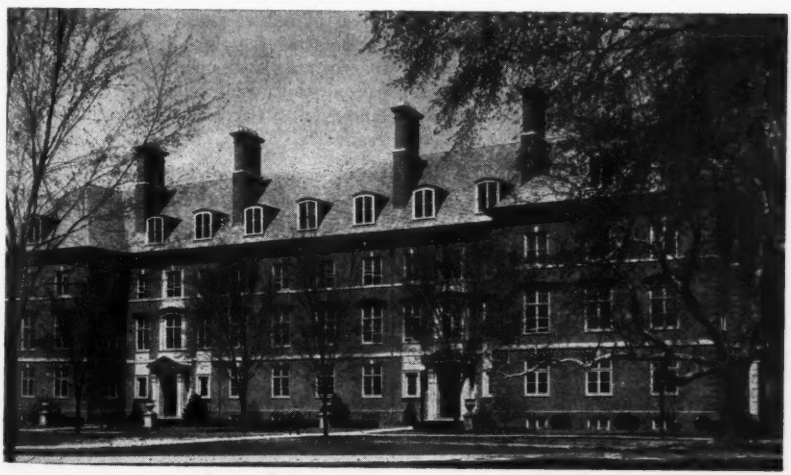
Most of those attending the meeting will have an opportunity to visit Robert Allerton Park, twenty-six miles southwest of Urbana-Champaign. The mansion house is complemented by formal and informal gardens, statuary and over a thousand acres of rich woodland, which serve as a public park. Allerton House is used regularly as a conference center for the University.

Coming or going to the Annual Meeting, tourist-inclined members may be interested in the Lincoln shrines around Springfield and New Salem—west of Urbana—or in Chicago and the Great

Lakes region northward. As one nears St. Louis on the west, or as one approaches the lake country of Wisconsin and Minnesota on the north, one finds rolling terrain in strong contrast to the Illinois plains. The latter, nevertheless, provide an experience in themselves, and without a doubt have in store a welcome for those attending the Annual Meeting of 1954.



Illini Union Building, University of Illinois, Urbana-Champaign



Gregory Hall, University of Illinois, Urbana-Champaign

Liberal Education in Professional Curricula*

By VIRGIL M. HANCHER
President, State University of Iowa

When your President invited me to speak on some aspect of the relation of liberal education to professional education, it occurred to me that one aspect of that relationship which has received very little consideration or discussion, as far as I can determine, is the use of the subject matter of professional curricula as a basis for liberal education.

No doubt we can start off by agreeing that some elements of a liberal education are essential to the development of the good citizen, and that the possession of those elements of liberal education by their graduates should be the goal of our state universities and of our land-grant colleges.

Having said this, however, we are sometimes at a loss to describe those elements in more precise language. What we mean is easier to recognize than to define. One of my distinguished predecessors at the State University of Iowa has said that a liberal education is more quickly recognized by its absence than by its presence. We implicitly sense the comprehensiveness and breadth of knowledge, the understanding and the insight which mark the liberally educated man. We recognize and value the tolerance, urbanity and breadth of spirit which come with a basic and fundamental knowledge of man, his society and institutions, their development out of the long past, and their place in the dynamic present.

We expect to find in the liberally educated man, therefore, the ability to ascertain facts and to act upon them; to know the society of which he is a part, and how it came to be what it is; and to possess the imagination and insights necessary to see the direction in which society is moving. We expect him to be able to make wise choices, both for the guidance of his personal life and for the collective decisions of the society of which he is a part. We expect him to know that knowledge is power and, even more significantly, that knowledge is freedom—freedom from disease and pestilence, from superstition and taboo, and from the fears and terrors that possess the mind and touch the soul of uncivilized man. We expect him to know that this knowledge, combined with vision and creative power, can harness the forces of nature and work for the establishment of the "good" society. These, indeed, are the elements of a liberal education which our state universities and land-grant colleges seek to instill in their graduates.

Two Obstacles

But there are two considerable obstacles to the achievement of this goal; time and money.

We must always be concerned with the time required in the educational process. Are we doing all that we should in the time allotted? Could we do as much work of equal quality in less time? These are questions we must always keep before us. Our curricular patterns must be selective and basic. We must decide between those things which can be learned best and most economically in college and those which can be learned best and most economically outside. The demands on the time of youth are becoming very great

* Presented at Association of Land-Grant Colleges and Universities, Columbus, Ohio, November 11, 1953.

in many lines. As long as military service continues, a medical student can hardly hope to enter civilian practice in less than nine years after graduation from high school. If he becomes a specialist, it may be fourteen. This gives an age range from twenty-seven to thirty-two. Deferred marriages or burdensome family obligations while studying are socially undesirable. Early marriages and child bearing are more fashionable than they once were; but they are difficult under present curricular patterns. Demand for highly trained and liberally educated professional and specialized personnel is very great, and it will increase. How can we meet the demand without unduly preempting the student's productive years?

We must also be concerned about the cost of education—cost to the student and cost to the institution. Each year added to the curriculum means a cost to the student of one thousand to twenty-five hundred dollars. It means added capital plant and faculty and facilities for the institution. The economic load will be very heavy. It is the misfortune of our generation and the one immediately following to be caught with a double burden. We face the prospect of an adult retired population greater than our country has ever known before and an infant and adolescent population seventy-five per cent greater than it was a decade ago. With our facilities strained to meet the inescapable need, we shall find it dangerous to engage in wasteful and unnecessary duplication. We must put aside the wasteful competitive and duplicating efforts which have been a disgrace to American higher education during the last decade and which have done as much as any single thing to bring it into public disrepute and to give aid and comfort to those who oppose and may even hate us.

Can we provide truly liberal and truly effective professional education more economical of time and money than we have done in the past? It is this possibility which I wish to explore with you today.

Complex Pattern

Our pattern of higher education in this country is exceedingly complex. We possess many kinds of institutions ministering to many kinds of people having many kinds of needs. No doubt each of them has its contribution to make. Perhaps no one of them has the complete answer to all our needs. Of these many types of institutions of higher learning, two are peculiarly indigenous to the American scene; the land-grant college of agriculture and mechanic arts and the four-year college of liberal arts. One is the product of legislation. The other is the product of slow growth and development. Each arose to meet a well defined need of our society.

Section 4 of the Land Grant Act (Morrill Act) of July 2, 1862, provides for the establishment of colleges:

> where the leading object shall be, without excluding other scientific and classical studies and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts in such manner as the legislatures of the States may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life.

It seems fair to say that the institutions contemplated by this act were brought into being to provide increased knowledge and skill for those who, at the time, were generally deprived of access to the colleges and universities of the day or who, because of their interest in agriculture and the mechanic arts, did not find in those institutions the subject matter which they cared to study.

We all know how the land-grant institutions have revolutionized American agriculture and have greatly affected progressive agriculture in all parts of the world. I had ample testimony to their worth and greatness this summer when I had the good fortune to be the guest of the University of Bristol (England) on the occasion of the celebration of the fiftieth anniversary of the founding of the Long

Ashton Research Station, now affiliated with that University. There many of the leaders of agriculture in Britain and the Commonwealth paid their high respects to the pre-eminence of American agricultural teaching, research and extension.

By the circumstances of their creation, the land-grant colleges were born free of the customs and curricular patterns of traditional colleges of liberal arts and traditional universities. They possessed a unique opportunity to develop new approaches to liberal and professional education. But, notwithstanding their excellent work in agriculture, have they fully realized the total opportunity that lay before them?

The Morrill Act provided that the leading object of the land-grant colleges shall be:

> . . . to teach such branches of learning as are related to agriculture and the mechanic arts . . . in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life.

While the Act does not exclude the teaching of traditional scientific and classical studies, it clearly contemplates that a liberal education may be obtained without them. It would seem logical to suppose, therefore, that the drafters of the Morrill Act contemplated that liberal education might be accomplished by teaching the subject matter of agriculture and the mechanic arts in a manner designed to produce both a technical and liberal education. But it appears that the development did not take place in this way. Perhaps the way was too uncharted, perhaps the weight of tradition was too great, perhaps the ease of another course was too beguiling for those who, three-quarters of a century ago, were the pioneers in the land-grant college movement. In any case, it appears that in meeting the need for that liberal and practical education, mentioned by the Morrill Act, the land-grant colleges found it more acceptable to introduce traditional courses from the liberal arts colleges or to establish what were in effect schools or colleges of liberal arts within their institutions. They did not, as far as I can discover, develop a new or different concept of how liberal education can be achieved.

To amplify this point, let us now turn to that other peculiarly indigenous American institution, the four-year college of liberal arts.

An American Institution

The four-year college of liberal arts, whether independent or university connected, is a peculiarly American institution. It is not to be found in Britain or Europe or elsewhere outside the United States except where it has been established by Americans or other persons having before them the model of the college of liberal arts as it developed in this country. Perhaps the closest approximation to the four-year liberal arts college in Britain is the newly established University College of North Staffordshire in the English Midlands.

I mention the establishment of this particular institution and the absence of other similar institutions in Western Europe, because we in the United States talk and act as though the maintenance of the great traditions of liberal education in the Western world are somehow dependent exclusively upon the four-year college of liberal arts as it has developed in this country. In doing so, however, we overlook the fact that the great liberal traditions, of which Western Europe has been the custodian for many centuries, have been handed down to us through educational institutions and educational systems which contain no colleges of liberal arts in the sense in which we know them. These great liberal traditions have been maintained and handed on, in the field of higher education, through universities and technological institutions which have taught, in a liberal fashion and in a liberal tradition, subject matter which otherwise would have become purely technical or professional.

To say this is not to minimize the importance of the colleges of liberal arts in this country. They have performed, and will continue to perform, an indispensable service for our people. But because they are so much a part of our life and tradition, we forget that other nations have carried on the tradition of liberal education without them. We forget that it is possible to become liberally educated by the teaching and study of professional or specialized subjects in a liberal manner.

I venture to put this proposition before you with great confidence because I have seen it done. I am a lawyer by profession, and I was an active practitioner for sixteen years. I hold degrees in law from Oxford University and the State University of Iowa. Law is one of the major professions and an exceedingly technical one. That the study and practice of law are, or can be, highly specialized pursuits would seem to be propositions that would require little argument. Whether or not a gift is made in contemplation of death, whether or not a remainder is vested or contingent, whether or not the rule against perpetuities applies to a bequest or a devise, are questions of the utmost technicality. It would normally be thought that the study of such questions or that the study of law could hardly be anything but a narrow, technical and professional pursuit. Nevertheless, during the years 1920–1922, I read law in the School of Jurisprudence at Oxford University, and in my judgment, the study of law in those years was as certain a means of becoming liberally educated as the pursuit of any academic major in any college of liberal arts in this country either at that time or since. It not only embraced the principles underlying the modern law of contracts, torts, real property and other basic subjects, but it also traced the historical and political development of English law and legal institutions from the time of the Norman Conquest to the present day. Further, it provided the student with a perspective on the vast legal development of the Roman world from the time of the Twelve Tables to the Code of Justinian, a broad sweep of almost a thousand years. Certainly such education is designed to stir the imagination and to open the windows of the mind.

Liberal Emphasis

Is there any reason why engineering and agriculture, architecture and pharmacy cannot be taught with the same liberal emphasis and the same liberal point of view that I found in the teaching of law in the Oxford School of Jurisprudence three decades ago?

It seems to me that a negative answer must be made to this question. However, lest you think that I am oversimplifying this proposition and basing it too completely on my limited experience, let me turn for an example to the field of engineering and particularly to the subject of engineering drawing. Not being an engineer, I would suppose that this subject could be excruciatingly dull unless it were taught with the purpose and techniques requisite to stir the student's imagination. The late Professor French, of Ohio State University, gave testimony to its cultural value by pointing out that apart from its practical utility, it can be used to develop "constructive imagination, the perceptive ability to think in three dimensions, to visualize quickly and accurately" and "to build up a clear mental image." And I am indebted to a life-long teacher of engineering drawing for the proposition that the subject can be taught in relation to the broader interests of our time and as a medium for the acquisition of a liberal education.

Engineering drawing, properly understood, is a method of communication—a method which can and does transcend national barriers and becomes international in scope. Mathematics is a method of communication by symbols, printing by signs, speech by sounds, engineering drawing by lines. Thus engineering drawing, treated imaginatively, becomes a part of the total problem of effective communication.

I am aware that much time has been spent on engineering curricula and that there have been argument and debate on the introduction of political science, history, economics and many other subjects into the engineering curriculum. But, bearing in mind that the time engineering students can spend in college is limited and that the pressure for inclusion of additional technical subject matter is very great, has anyone considered how the normal subject matter of engineering can lead to the civilizations of the Nile and of the Tigris and Euphrates, to the construction of the temple to Jupiter at Baalbek, or of the Parthenon at Athens or of the Colosseum at Rome? Surely engineering drawing is not unrelated to ethics or logic, or to economics, or to the graphic and plastic arts, or to the temples which have housed the great religions of mankind. Engineering drawing can be taught with deadly dullness or it can be taught so that it will open the windows of the mind. Let the contribution of the teacher of engineering drawing, as my friend so well put it, "be like flashes of light stabbing through the dark areas over and above and beyond his subject matter, illuminating for one bright moment vague spots in the engineering educational shadows." [1]

Doubtful Proposition

While in general I would support the proposition that there are some things which every liberally educated man should know, I fear that we have been led into error sometimes by believing that the study of certain subject matter inevitably results in a liberal education. This is a doubtful proposition. It is nearer the truth to say that there is no subject matter, worthy of a place in the curriculum of a modern land-grant college or state university, which cannot be taught either as a professional speciality or as a liberal subject.

For example, there is no specific efficacy, for one seeking a liberal education, in a knowledge of the declension of Latin nouns or the conjugation of Latin verbs. One who learns a foreign language for the purpose of purchasing a ticket on an airplane or ordering a meal in a restaurant or in order to sell more automobiles or hats or shoes is probably not studying it in the spirit of liberal education. On the other hand, one who studies it and its literature in order that he may have his eyes opened to the nature and extent of a new civilization different from his own is in process of obtaining a liberal education. I have long thought that the general principles of the law of evidence should be mastered by every graduate of an institution of higher learning. It has implications and value far beyond its technical significance to the lawyer. Mathematics is an international language. It can be taught as an intellectual exercise, completely divorced from all social significance or reality. Or it may lead to the land measurements of the Egyptians, the construction of the Pyramids, or the dimensions of the solar system. Knowledge may be so departmentalized that chemistry can be taught in courses in chemistry and English composition be taught in courses in composition so that never the twain shall meet. Or chemistry may be taught so that every teacher of chemistry is also a teacher of English speech and composition, just as every teacher in every subject should be. He should possess a mastery of the fundamentals of the language and should possess and be able to induce in others a sense of style, for, as Whitehead says, "Style is the ultimate morality of mind."

I have dwelt on this point at some length because of the apparently erroneous belief that land-grant colleges must duplicate the work of liberal arts institutions in order to provide their students with that attitude toward life which we believe to be characteristic of the liberally educated man. What seems to be completely overlooked is the possibility

[1] Higbee, *Journal of Engineering Drawing*, Vol. 12, series 34, Feb., 1948; p. 8, at p. 24.

of teaching professional and technical subjects in a liberal manner, in other words, providing for a liberal education in professional curricula.

Each of us has had the experience of finding subject matter come alive because of the presence of a great teacher. We know that the influence of the teacher is determined not by his subject matter but by his handling of it. Otherwise the greatest teachers would all be in one field. But we know this to be contrary to fact.

Opening Vistas

What we need in our land-grant colleges and universities and institutions of technology are teachers of professional and specialized subjects who see their subject matter in relation to the whole field of modern learning and modern civilization. In an institution possessing such teachers and likewise possessing an imaginative and intelligent student body, liberal education is bound to occur, whether the subject is contracts or classics, physics or politics, anatomy or art, soils or sociology, history or hydraulics. To use words which may have become slightly shopworn and overworked in recent years, we need teachers who teach with a sense of the "infinite and urgent." We need teachers who see their subject matter not only as a means for developing techniques and skills, vitally important as these are, but also as the means for opening vistas which will challenge and inspire the student's imagination.

The land-grant institutions, having been created free of the habits and traditions of the past, have an unequalled opportunity to explore and develop the possibilities of liberal education in their professional subject matter. It is not a legitimate objection to say that the curriculum is too full and that there is no time for this kind of education. True enough we hear that the subject matter of each professional field is increasing, and, therefore, that the curriculum must be lengthened. This rests on the fallacy that everything must be taught. Yet what a fallacy that is! No lawyer ever learned all the law he practices in the school or college in which he studied. The same is true of the doctor, the farmer, the engineer, the journalist and of every professional man. No institution dares demand the time necessary to teach its students all there is to know. It is the responsibility of the institution, perhaps its most important responsibility, to determine what is fundamental, to teach that which is fundamental, and then to put the student on his own. We need to review our curricula often. We need to view them with a practiced eye and to re-evaluate and eliminate and consolidate until we have only the fundamentals remaining. What we teach should be basic. It ought to lead the student out to those things which he can learn for himself, and it should be taught with that imagination and vision, that liberality of mind and spirit, necessary to assure that what the student learns will be learned in relation to the whole complex of modern knowledge and modern civilization.

Widened Horizons

If this can be done, thousands of young men and women who otherwise might become merely narrow technicians will become not only able and effective citizens, but even their professional competence will be heightened, because their eyes have been opened and their horizons widened to things far beyond their childhood gaze. And because we have taught them imaginatively, they will be stimulated to be students as long as they live.

If this can be done in your institutions and in ours, we shall have succeeded in creating a new form of American education, a form both liberal and competent, complete and economical, and, therefore, admirably adapted to serve the needs of students, of our institutions and of society as a whole.

In my judgment, this possibility is the most challenging one which has come to American education in many years.

It Is Time for the Laymen to Come In*

By J. F. CALVERT

Professor and Chairman, Department of Electrical Engineering, Northwestern University

Introduction

The Chairman of the Humanistic-Social Division has asked me to speak in relation to the abilities and work methods required for the solution of new and unfamiliar engineering problems.

I imagine that many have wondered why, of all living creatures, man has been so singularly and bountifully endowed with problems. Although the situation remains inescapable, what to do about it has led to quite interesting speculations. It is common practice nowadays to ascribe our chief difficulties to the fact that scientific and engineering advances have outrun our abilities to use them. One ingenious theory undertakes to get rid of our responsibilities in the dilemma by simply restating the problem. The theory credits our ills to the machine age. The idea possesses an interesting genealogy for, while in the middle ages it was popular to assign the evils of the world to the work of the devil, modern writers have managed to endow "the machine" with a personality and to then make it their whipping boy. The appeals are similar, and equally satisfying, since each presents something with the likeness of a human being which the majority may decry. However, to replace a personality of doubtful existence by simple physical equipment, bears all the earmarks of a modern miracle and, oddly enough, places upon its authors a certain responsibility for technological unemployment.

We can abandon this approach, for in education we have one which enjoys even greater popularity. Stripped of academic adornment, it says: If we have more study in the humanities relative to the amount in science, we may expect a better world to live in. I take the liberty of passing along two illustrations from several which were summarized in a recent paper by Rhodes R. Stabley, published in the Bulletin of the A.A.U.P.

In the words of Mr. Stabley one prominent educator "held that a liberal arts program with its stress on human understanding and with a positive approach to essential values, is of greatest importance to society." And from the same paper I learned that the president of a well known university contends that students with a good liberal arts education are "the least likely to become associated with communism."

There have been many expressions of faith like these and, though occasionally vague, it is quite clear that we all believe in them. The liberal arts faculties ask us for more time, and we in engineering work busily on curricula to see that this is accomplished. There is the implication of success if only we apply the formula. But, we have had pilot plants going for many decades; should we ask how they are getting on? Do we really find that morality and high purpose among college graduates can be measured by the relative number of college hours expended in one area as compared to those in another?

Then there are the scientists, pure and applied. Many of us feel that our brands of education must afford the best preparation for life in this technological age.

* Presented before the Humanistic-Social Conference, Annual Meeting of A.S.E.E., University of Florida, June, 1953.

I shall refrain from quoting any of our people because I live among them, and so far have liked it. Besides I cannot recall how many times I've said: "Now, let us talk about an engineering stem for the liberal arts program." So there still exists in my mind a slight gnawing fear that even we could appear a little self-satisfied, at least to the uninitiated.

After what I've said thus far, I trust that the ideas yet to be expressed in this paper will in no way appear revolutionary. Now one may be led to suspect that since in all education we seek to know the truth as we are enabled to see it, our approaches may have something in common. In consequence, there may be unearned increments, carry-overs into areas for which the methods were not really designed.

I want to suggest that, at least for the engineer's training, something further might be gained were greater efforts made to relate historic truths and the recognition of values to rather specific present day problems. I think it not inconsistent with gaining understanding to have our engineering students given more practice in distinguishing, stating, and attempting to propose solutions for problems in the broader areas of their future work. It is the consideration of such possibilities which I believe your chairman had in mind when he established the theme for this meeting. I plan, now, to say something of the principles of problem-solving for technical engineering work and then to conclude with a few remarks on the possible applications of somewhat similar principles to the training of future engineers for the more general phases of their professional careers.

Problem-Solving in the More Technical Areas of Engineering

This discussion of engineering problem-solving will be divided, for clarity, into four sequential parts. Actually, an engineer is rarely able to work through a problem in such an orderly fashion. Indeed, he may travel back and forth many times from one phase to another before he achieves a solution. Nevertheless, just as it is helpful to the engineer, so it may be to those of you interested in his work, to have a brief, if somewhat idealized, delineation of his more creative activities.

Discovery of a Human Need

All problems seem to stem from the discovery of a human need or want. At first the need may be expressed, or even unexpressed and, if the latter, evidenced only by a state of discontent. Not surfeited by problems which are thrust upon us, a certain number of engineers intrigue themselves with potential needs, which appear largely through the imagination. A man thinks, "If only I could produce thus and so, people would like it; I could be in a new and, perhaps, more rewarding business." If a want can be satisfied entirely, or in part, by the application of knowledge of the physical sciences, it becomes an engineering problem. In our country we usually approve of this sort of activity and certainly many enjoy it.

However, it is a fact that the engineer often fails to recognize even the actual existence of a need, not to mention those which exist potentially. The reasons are not too surprising. In college he has learned how to solve problems which the teachers or the texts brought to him. Rarely, if ever, did he have to find one on his own. But there are ways around this. Human needs can even be organized into groupings and the student can define a specific problem. Without trying to produce a logical table of these needs, there come to mind—the preservation of life, safety, transportation, communication, the reduction of physical labor, the economic use of materials, the preservation of resources, and also the development of recreation and amusement facilities. In going concerns, such as the telephone business, there are groups of engineers assigned the task of working eight hours a day with the business as they expect it to be three to five years hence. Colleges provide little practice for this sort of or-

ganized thinking and almost none for those men who may contribute substantially to the creation of a new form of endeavor. On this basis, it might be desirable were we more concerned with developing the student's sensitivity to such existent and potential needs. To become most effective the engineer's training might give more directed practice in observing social and physical surroundings, practice in listening and evaluating, and practice in listing observations for further study.

Statement of the Problem

Having become convinced, though not necessarily by a completely logical process, that a legitimate problem exists, the obvious next step for the engineer is to get it stated clearly. This might be done in one of several ways, but a representative form was suggested to me by the late Dr. Robert H. Seashore, Psychologist at Northwestern University:

(a) The object is to design: .....
(or) to produce: .....
(or) to organize: .....
(or) to adjust: .....
} And here the engineer must state what it is.

(b) In order to overcome the following obstacles: ..... } And here he must set them forth as completely as possible and attempt to indicate relative importance.

(c) In such a way that the following specified aims will be achieved: } And here, too, he must set forth items showing, perhaps, necessary minimum requirements below which he should not go, and maximum values beyond which no appreciable advantage is to be gained. A grading procedure is desirable for comparing alternative solutions (when discovered) which fall within these bounds.

The engineer should not expect to advance in one leap from the recognition of a human want in nebulous terms to such an accurate statement of the problem, but he should strive for such a statement with minimum delay, even though planning to hold his initial definitions as tentative. Quite often it is practicable for him to start the search for an actual solution *after* the problem has been stated in accord with these three main items, but *before* all measures for relative evaluations have been established.

The Synthesis of Potential Solutions

The teaching of science and of engineering relies to a large extent upon analysis (quite mathematical in character) for both generalization and for demonstration. At this point two simple definitions may be helpful. Let us say that a "basic fact," or "law," is a concept we can use more often than some other relation, and that mathematical-like statements are ones phrased in a language which can be employed without ambiguity. We lump these together under the term "fundamentals" and emphasize their use in all scientific education; in fact, their manipulation forms a large part of the "scientific method." At times, one detects reverence, even mysticism, in the use of these terms; but, I believe that in both scientific and engineering education, while we emphasize facts and techniques of analysis, we actually have produced only a few procedures (some of which are mentioned in this paper) for developing a sort of wisdom in the use of these teachings. To a large extent, we simply trust that from experience in research or engineering

practice, this wisdom will grow in a somewhat undefined manner.

In engineering we know that truly new products and/or organizational procedures are not often born as the result of pure analysis, but are synthesized by bold thinking—first in qualitative terms where they are painted in sweeping strokes with a broad brush. Sikorski speaks of intuition as the "forerunner of knowledge," which tells of the correctness of things that later may be proven by observation and analysis. Synthesis stems from the imagination, a series of forms, colors, sounds or images appearing within the mind, and intuition is that sense of correctness which alerts you for a conscious check. The check itself may be either preliminary and not entirely conclusive, or it may be carried out by the stern processes of analysis. The search for a solution calls for quick tentative uncertain probings, and only the accurate check is in accord with flawless logic. Creative work in engineering calls not only for a knowledge of science and industry, but also for the spirit of art; yet there are definable abilities and work methods which can be useful in the initial stages of problem-solving, and which a man can develop through practice.

Two of the special abilities we might call idea fluency and originality. Idea fluency could be defined as a quantitative concept, concerned both with the recognition of problems needing solution and with the proposal of numerous possible procedures for the solution; while originality could be regarded as qualitative concept, the ability to produce ideas which are uncommon, clever, or remote from the traditional.

First among the work methods is that of converting the statement of the problem from one goal to a sequence or group of sub-goals, where, if each is attained, the whole or single major objective will be achieved. There comes a rather long "soaking in" process in which one gathers facts and hunches (appropriately tagged), and then lives with these day and night —always with the main and tentative sub-goals in view. Library searches bring to mind well defined procedures, but there is an art in asking pertinent questions of experts and then actually using the answers in research. Today this art is largely self-taught.

Conference Approach

There is at least one conference approach which should be mentioned. In the past, it has seemed to me that the chief and often fatal drawback of many group discussions was that members of a committee not only could but would "shoot full of holes" almost any newborn idea before it had time to get its legs under it. A procedure for avoiding this difficulty, recently brought to my attention by Frank R. Benedict of the Westinghouse Electric Corporation, bears a mild resemblance to the game laws. It is agreed at the start of a meeting, and then strictly adhered to, that for a time no man may enter a destructive remark. No one speaks except to get onto the blackboard a possible method of solving the problem. An optimistic or enthusiastic outlook is encouraged. This is continued until all suggestions seem to have been extracted from the group. After this idea stage has served its purpose a classification of the possibilities is undertaken, but, again, without destructive criticism. Next, the relative evaluation of ideas, is undertaken, but still with some spirit of forebearance. In the final stages, however, at this or a subsequent meeting, the cold hard restrictions are firmly introduced to eliminate the unpromising proposals and, in fact, to choose that or those upon which action will be taken.

As the work proceeds sub-goals must be rearranged, modified, discarded, and replaced as one checks for matches and mismatches between tentative solutions and the written sub-goals, main goal and human want. This calls for the development of another ability which might be called mental flexibility. It involves both the willingness and the ability to change "set," or viewpoint, or the mental picture

of the procedure to be used. It is objectivity but with the idea of observation followed by action.

One standard procedure employed in the solution of physical problems is to attempt the replacement of the original situation by a much simplified version, or model, which the investigator believes will act in a manner similar to reality. To be useful, the fiction introduced should be one which will yield a solution, and it should be one onto which the engineer can add complexities as he becomes better able to achieve solutions. His purpose is to construct and solve successively more involved models which progressively take on greater and greater resemblance to the real or originally assumed physical situation.

All such efforts in creative work or problem solving are hard and decidedly wearing. They always engender fatigue; often exhaustion and a sense of utter frustration. There results a loss of mental power, verve and flexibility. The engineer must not only recognize the symptoms in his own behavior, but should develop for himself his own ways of minimizing the duration of the ensuing periods of relative uselessness for the job at hand. He must devise ways to regain strength, enthusiasm and flexibility.

Finally, let us suppose that the engineer finds one or more potential solutions to his main or original goal. If he has found more than one, he must weigh their relative merits. Sometimes he is forced to carry along two or more developments, but this is a costly procedure in the use of manpower, and usually of material. Hence, as early as possible, he must devise ways of testing one procedure against another. Often both long and short term aspects of his problem are to be considered. He asks such questions as: How will this affect sales or labor or financial policy this year and five or ten years from now? On problems of very broad implication he may be the one who must ask, "How will this affect, in a given region of the country, income, the preservation of natural resources, or general human welfare?"

The Selling Problem

Throughout any development, as well as at the end, the engineer must sell, and sell, and sell. He must secure funds, quiet the skeptics and faint of heart, enthuse personnel, gain time, persuade vendors of materials to speed lagging deliveries, secure compromises between conflicting opinions within his own group without watering down the ultimate goal; and, at all times, he must keep the job moving. Then, oddly enough, to be successful he must seek general acceptance of the finally created result.

Training for Problem-Solving in the Less Technical Areas of Engineering

Engineering is dependent upon study in many areas: mathematics, physics, chemistry, business economics, English; and, I may add, very appreciably upon a continuing study in the humanities, extending over many years. But engineering is no single one of these. American industries are dependent upon materials, trained workers, economics, scientific discovery, and the law. But, American industries as we know them today, particularly in the durable goods areas, would not exist on the basis of these alone. These industries were planned and put together by engineers. In consequence, engineers in swelling numbers are assuming the rolls of both major and minor executives. It is reasonable to expect that in the future they will be consulted in increasing numbers in relation to government and world affairs where their particular planning skills and experience can be of value. Potentially, these are the kinds of men whose growth we are trying to influence through their college experiences.

It is well recognized that the engineer must prepare for problem-solving in many areas considerably removed from the purely technical. It has been generally assumed that some exposure to the

conventional courses in the humanities would provide this needed preparation. It is considered self-evident that such experience affords an opportunity for developing a richer intellectual life by providing access to knowledge and a desire to know more of man and of the universe which he is privileged to see. *Also*, it has been *tacitly* assumed by many that such educational experience has been close to the best possible for preparing a man to take appropriate action in the affairs of his adult life. But, by itself, the latter assumption seems not too conducive to changes in educational methods and, in consequence, may inhibit potential improvements. So, at least for the purposes of this discussion, I shall contend that to blindly apply this latter belief to the future of engineering education, certainly would represent an unwarranted assumption of faith in the status quo. It might better be said to represent an improper continuation of time-honored shibboleths passed along by the static minded educators of the past.

Along with most in engineering and science, I believe that abilities for problem solving are developed through doing. A little may be learned of this through reading and observation, but much more through practice. We need to ask now: What are the obstacles to a further development of these needed educational experiences?

First, let me record a few observations. From time to time I have asked colleagues from various parts of the campus what they thought of the following as representative of subjects for doctors' dissertations:

(1) A discovery in the physical sciences.
(2) An invention or all new design in engineering.
(3) A novel.
(4) A musical composition.
(5) A painting.

Each presents possibilities for truly creative work, yet the foregoing are arranged in what has appeared to be the decreasing order of acceptibility. Rather scholarly explanations were advanced by some; other wondered if there were not just two really important reasons: the decreasing possibility for gauging results coupled with a genuine and, in our times, a particularly commendable desire to avoid the bizarre.

Related Observations

There seem to be related observations. One gains the impression of growing trends in many areas of study toward the collection of facts, the employment of statistical-like procedures, emphasis on minute detail, and the constant employment of analysis for refinement. All are necessary, and in certain areas, such as the social sciences, perhaps these are particularly desirable as means for "quantizing" hitherto qualitative information. Perhaps the danger today is not that we fail to do enough of a scientific nature, but that in evaluating research we fail to distinguish facts and techniques from creative work. Surely, the standards we set for our research affect our undergraduate teaching. I suspect, in consequence, we may tend to teach what we can measure and are a little too pleased when it comes back neatly packaged in punch boards, blue books, and term papers none the worse for wear. Whether we teach a fundamental law of physics, a manual skill, the appropriate substitution in a differential equation, or accepted forms for written English, perhaps we should recognize that, while once new and novel, these are now accepted facts, data and techniques. Like a knowledge of materials, tools and the skills of true artisans, these are essential, but by themselves will not develop the wisdom of the planner or the architect.

At our present meeting we intend to look at the engineer's training in the humanities with problem solving in mind. By way of introduction, consider what are perhaps our most obvious problems of the day—social and political affairs

on a world wide basis. All of us are becoming increasingly aware that ideas, almost as if by osmosis, seep both ways at once through all political boundaries. The great question is: Which will predominate? But the more practical questions are: What do we believe? How strongly are we dedicated to these beliefs? How aggressive will we be in spreading our beliefs? And then, in relation to the present discussion: What may be said of education as a preparation for those who must point the way to successful procedures?

During the past century our colleges produced men of conviction and zeal. It seems to me now, that beginning in the twenties, we became a little uncertain, self-conscious, and for a while sophisticated; and so we tended to produce samplers, tasters, critics, and passive observers. Now during my life time, we have experienced expanding dynamic political forces motivated by philosophies of empire and rights to leadership, theories of a dominant race and human destiny, and, more recently, an aggressive and frightful cult called communism. All have been authoritarian and each more barbarous than the last. We found the passive outlook was not good enough, probably not even good enough to provide for our own survival. Apparently, we've decided there is greater power in being for one ideal than there is in just being against another. I think it is in consequence that we have had a revival in the emphasis on human rights and principles of self-government. These rights were succinctly stated in an address in 1946 at White Oaks, Maryland by Dr. M. A. Tuve as: the right to know; the right to believe; the right to differ; and the right to be an individual. For our purposes here we may add as principles: the sovereignty of the people; and the provision through the forces of law for reasonably prompt justice and for means of peaceful change. These have been reemphasized in school, press, and statements of public policy to serve as motivating forces. Certainly they are working methods whose values have been proven over the centuries, and so we justly consider them absolute essentials. Yet by themselves, even these are not the strongest motivating forces. Somewhat to our disappointment, they did not sell too well, particularly in the Orient; and so we were inclined to say that the first needs of peoples were food and clothing.

Powerful Forces

We remember that survival was once called the first law of nature, but while it may have been the first from an evolutionary point of view, it is demonstrably not always the most powerful force; so let us ask, what beyond survival do people want? I suspect the most persistent is evidenced by a desire for the approval of their associates, and then again they yearn to respect that which they will see when they look inwardly upon themselves. These hoped-for-approvals are measured against certain standards and we may as well face it—the most powerful forces in the minds of men, it appears, have been and are religions, philosophies and ethics. Whether the end results have been for the long time good or bad, only these forces seem to have brought purpose and satisfaction into human lives, and only to these will peoples become truly dedicated.

While, I believe, we will return again to the old premise that for understanding we must give most thought to human motivations, I am fully convinced that, more than ever before, we must be concerned with problem-solving—plans and actions based on a knowledge of these motivations. With the engineer's education in mind, let us take a further look.

During the past century, we in the western world have found our ideals and purposes much like drops of mercury on a table—though unable to pin them down still we could not deny their shining existence. Without extolling a special viewpoint we should open wide the windows that each student, from his own point of view, may not only see these bright spots of light which lie before him, but recog

nize them as the reflections of light from a great single source—one which should influence the whole—his studies and his life.

Suppose for the moment that we were to learn to do just this with care, candor and humility. Then, let us look at problem solving for the engineer in relation to his general studies. Consider his opportunities to view labor-management relations; race-relations; area developments (such as TVA) here and abroad with their related soil conservation, population and associated problems. (And here we must add a consideration of the ever present need for individual motivation and incentive.) From the same basic viewpoint consider the student's opportunity to study the effects of tariffs and subsidies; and, let us add, to investigate some of the public school problems of the day. Let us ask, does he have practice in finding, stating, and limiting problems? Against what does he measure the value of his goals? Does he consider potential opposition, and limitations in the ability to achieve these goals? Does he synthesize potential solutions in terms of long and short time aims? Does the student consider to whom he would "sell" an idea and how he would proceed to do so?

It Is Time for the Laymen to Come In

Now, at last, I have come to the title of this paper. It is obvious that within the time available, we cannot hope to make of student engineers, scholars in any of the areas of the humanities. In this sense the engineers remain laymen. Yet, they are expected to become men of action, busy with problem-solving and decision making, at home and over-seas, in broad areas of human affairs. There are more than three hundred thousand engineers in this country alone. Their recommendations and decisions will affect the lives of many. True scholars in the various specialized areas of the humanities are fewer in number, and most of these remain at the colleges. It is upon laymen such as the engineers that we must rely for many changes and, hopefully, we say for improvements. There exists a responsibility to develop these men not particularly in the direction of scholarly attainment in specialized fields, but for problem-solving based upon a working knowledge in many areas. It's for all sorts of reasons I wish you well with our common responsibility; I hope you feel as I do, that it is time now for these laymen to come in. They should be helped to come fully into their own through the training we give them—particularly through the way we encourage them, not only to learn and to understand, but to discover problems, to state problems, to solve problems and to reach decisions for appropriate action.

An extensive bibliography is available to anyone who wishes to write the author for a copy.

Free Film Available About "Mechanical Engineering"

Michigan State College has completed a vocational guidance film about "A Career in Mechanical Engineering" which they have agreed to loan to interested groups without charge, except for shipping costs. This 20-minute colored film shows the nature of mechanical engineering, job opportunities, and training given future engineers.

Designed primarily for showings before high school groups interested in engineering careers, the film includes scenes of training on the Michigan State College Campus, and professional engineers at work in industrial plants. A mimeographed script accompanies the film. Requests for the film should be sent to Professor W. E. Libby, School of Engineering, Michigan State College, East Lansing, Michigan.

Proposed Amendment on Membership Dues

An amendment to ASEE By-Law IV relating to dues of individual members will be submitted to the Society membership for vote in April. This change in dues was recommended by the Committee on Society Finances in June 1953, after careful examination of the financial operations of ASEE. The report submitted by the Committee on Society Finances was approved by the Executive Board of the ASEE, the Engineering College Administrative Council and the Engineering College Research Council. This report was published in the September 1953 issue of the Journal of Engineering Education. The General Council discussed this problem at its meetings in June and October 1953. In the October meeting, the Council voted unanimous approval of amendments to increase the dues. The following amendment embodies the same dues rates as that previously voted upon by the Council but is a simplification. It was unanimously approved by the Executive Board and is now being resubmitted to the Council for vote.

Proposed Amendment to ASEE By-Law IV

"Individual Members

Within the ceiling limits for dues hereby established, the dues of members may be adjusted annually by the General Council at the same Council Meeting at which the annual budget is considered. The dues shall be so adjusted within the ceiling limits hereby established that over a reasonable period of years the Society shall not incur a deficit that in the opinion of the General Council might endanger continuity of operations.

The ceiling on dues shall be $7.00 per year for those who have not reached their 36th birthday at the beginning of the fiscal year (July 1) and $10.00 per year for all other individual members. Except for the first year after the adoption of this By-Law, the increase in dues approved at any one time shall not exceed $1.00 for individual members.

During the first year after adoption of this By-Law, the dues for individual members will be $6.00 for members who have not reached their 36th birthday by July 1, 1954, and $8.00 for all other members.

Institutional Members" (The remainder of By-Law IV is unchanged).

Present Wording of By-Law IV

IV. The annual dues shall be as follows:

Individual Members

1. Librarians and grades under Associate Professor	$ 5.5
2. Associate Professors	6.0
3. All others	7.0

Institutional Members

1. Active Members	
a. Participating in both Institutional Councils	$50.0
b. Participating in only one Institutional Council	35.0
2. Associate Members	50.0
3. Affiliate Members	25.0

A Proposal for Obtaining Necessary Income for the Society

By HUBER O. CROFT

Chairman, Committee on Constitution and By-Laws; Past President, ASEE

President Grinter in the November 1953 issue of the Journal gave the following facts concerning the financial operations of the Society:

1. The dues have been increased only from $5.00 to an average of $6.25 in the past twenty years.
2. A deficit of $1,700 was experienced last year and a budgeted deficit of $3,700 is occurring this year.
3. The cost of publishing the Journal now amounts to an annual charge of $30,000 or 40% of the income of the Society. Investigations of other methods of printing the Journal indicate that very little if any savings can be anticipated.
4. The Society operates with a very small headquarters staff and low overhead expense. At least one additional clerical worker should be added to the office staff.
5. The Society pays no rent for its headquarters space and furniture.
6. The cost-of-living index has just about doubled since 1946.
7. The ASEE has maintained a balanced budget until last year by a vigorous expansion of membership and a substantial increase in other Society revenues. However, these efforts have themselves entailed additional operating costs.
8. In order to maintain the Society in a healthy condition an increase in the dues of individual members is essential.

On the opposite page is shown a proposed substitute for the present Fourth By-Law of the Society which pertains to the annual dues of the Society. You will be asked to vote on this proposal by a letter ballot which will be mailed to you in April, 1954.

The original plan for increasing the dues of individual members was suggested and approved by your General Council and the proposed wording of the substitute By-Law has been approved by your Committee on Constitution and By-Laws, consisting of: H. H. Armsby; H. P. Burden; G. A. Marston; K. B. McEachron; H. P. Rodes; and H. O. Croft, Chairman.

The officers of your Society recommend the adoption of the substitute By-Law and ask your support.

ASEE Summer Institutes—1954

Science and technology are moving rapidly ahead in broad areas which hold significant promise for the future of engineering. In order to assure maximum progress in engineering education and to expedite the translation of new fundamental concepts into engineering practice, the American Society for Engineering Education is inaugurating this year a series of conferences to be known as Summer Institutes. This program will help to implement the recommendation of the ASEE Committee on Engineering Education that modern physics, including nuclear science and solid state physics, should become an essential study in engineering education.

Each Summer Institute will deal with a specific subject matter area. The purpose of the Summer Institute is to seek out and clarify fundamental concepts, to assess the material as to its importance in engineering education, and to arrive at a logical orderly pattern for teaching purposes. By this positive approach, it is hoped to bring engineering education into closer proximity to the significant new developments which will affect its future. In these conferences, the divergent viewpoints of the research engineer, the scientist, and the educator will be brought to bear upon the problems.

Two Summer Institutes are planned for 1954—one in Sold State Physics in Engineering Education and the other in Nuclear Physics in Engineering Education. Both conferences will be financed by grants from the National Science Foundation. Each Summer Institute will consist of a working conference of 20 to 30 leading authorities in the particular field who will make a comprehensive analysis of the material and lay the groundwork for the open conference. The open conference will feature about 6 to 8 of the participants of the working conference, discussing important fundamental concepts and organization of the subject matter as it relates to engineering and engineering education. There will be ample opportunity for open discussion by those in attendance.

These conferences are supported in part by grants from the National Science Foundation. The American Institute of Physics is cooperating in the Nuclear Science Foundation.

Solid State Physics in Engineering Education

University of Illinois—March 8–10, 1954

This will be a working meeting of leading physicists and engineers specializing in this field. Attendance by invitation only.

Carnegie Institute of Technology—June 21–25, 1954

Open to engineering and physics teachers. Attendance will be limited to 150. For information and registration forms write to Professor John W. Graham, Carnegie Institute of Technology, Pittsburgh, Pa.

Nuclear Science in Engineering Education

Columbia University—April 22–24, 1954

This will be a working meeting of leading physicists and engineers specializing in this field. Attendance by invitation only.

Northwestern University—September 7–11, 1954

Open to ASEE members. Attendance will be limited to 100. For information and registration forms write to Professor Robert L. Young, Technological Institute, Northwestern University, Evanston, Ill.

• • •

ASEE Summer Schools—1954

The following Summer Schools, sponsored by ASEE Divisions, are open to ASEE members. For information and procedures as to registration, please write to the person indicated in connection with the particular Summer School. All of the Summer Schools at the University of Illinois either precede or follow the Annual Meeting so that those in attendance can combine Summer School attendance with attendance at the Annual Meeting. The program for the Annual Meeting of the ASEE will be mailed to Society members during the last week of April.

Economics of Engineering Summer School sponsored by the Engineering Economy Commitee.

Theme: "An Evaluation of Analytical Techniques of Engineering Economy."
Time: June 12–13, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Professor Arthur Lesser, Jr., Head, Industrial Engineering Dept., Stevens Institute of Technology, Hoboken, N. J.

Electrical Engineering Summer School sponsored by the Electrical Engineering Division.

Theme: "The Elements of Design of Digital Control Circuits."
Time: June 18–20, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Dr. L. V. Bewley, Dean of Engineering, Lehigh University, Bethlehem, Pa.

Summer School in Advanced Engineering, with Emphasis upon Development of Creative Thinking jointly sponsored by Educational Methods Division and General Electric Co. Attendance by invitation only.

Time: Aug. 30–Sept. 4, 1954. *Place:* Schenectady, N. Y.
Information: R. H. Buescher, Technical Education, General Electric Co., Schenectady, N. Y.

Workshop for Humanistic-Social Study Project sponsored by Humanistic-Social Division.

Time: June, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Professor Sterling Olmsted, English Dept., Rensselaer Polytechnic Institute, Troy, N. Y.

Engineering Mechanics Summer School sponsored by the Engineering Mechanics Division.

Theme: "Evaluation of the Engineering Significance of Graduate Training in Mechanics."
Time: June 11–12, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Professor Dan Pletta, Virginia Polytechnic Institute, Blacksburg, Va.

Summer School sponsored by the Mechanical Engineering Division.

Theme: "Teaching of Machine Design and Manufacturing Processes."
Time: June 18–25, 1954. *Place:* University of Illinois, Chicago, Ill.
Information: Professor K. E. Lofgren, Machine Design, Cooper Union, New York, N.Y.

Correction

The talk of Prof. H. E. Hoelscher of the Johns Hopkins University at the National Capital Area Section meeting this fall was reported incorrectly in the November issue of this *Journal.* Prof. Hoelscher discussed the report of the Johns Hopkins Educational Committee. This was a general report and not directed at the Hopkins Program specifically. The Hopkins does *not* provide a split curriculum, and has *no* five year undergraduate program in Engineering of any title. The Hopkins New Plan discussed by Dean Roy (not Ray, as reported in the same issue), provides a maximum amount of individual freedom of choice for the undergraduate student, emphasizing the importance of the fundamentals of mathematics and the basic sciences for students in the Engineering School, while permitting them to progress in their studies at a rate dictated as far as possible by their own talents and abilities.

Survey of Engineering College Needs for Basic Research in the Engineering Sciences*

By RALPH A. MORGEN

Program Director for Engineering, National Science Foundation

Introduction

In the past two decades there has been a profound change occurring in the philosophy and needs of engineering education. A growing emphasis is being placed on the importance of graduate education and the consequent need for more research as a concomitant part of the process. The concept of the engineering sciences has developed as a necessary tool to accomplish the needs of advanced engineering education to supply the practicing engineer with the information needed in light of rapidly advancing technology.

Since graduate education is expensive compared to undergraduate education, the problem of financing this new program is a vexing one. During World War II and subsequently, the engineering colleges have had the opportunity to finance this growing graduate program through contract research with funds largely arising from federal agencies charged with national defense. It is recognized that continued support for the graduate research program is needed.

This survey was undertaken with the thought of determining several factors: First, the present status of graduate education and research in various engineering colleges? second, the potential now extant to perform the necessary task of increasing the supply of engineers with advanced degrees and third, to make a rough estimate of the minimum financial needs to meet the requirements.

Although some data in this study are presented in statistical form, the methods of data collection and analysis do not permit a strictly quantitative interpretation of the figures. The statistics should rather be viewed as essentially a gross indication of the general magnitude of the problem.

The study was confined to the 149 educational institutions which have one or more undergraduate curricula accredited by the Engineers' Council for Professional Development. Of the 149 institutions, two are service institutions, the United States Coast Guard Academy and the United States Naval Postgraduate School. These two were not included in the survey. The remaining 147 institutions were contacted and specific answers received from 139 of the institutions. Of these 139, 63 institutions were contacted personally by direct interviews. Rather detailed letters were received from key † persons at the other 76 institutions.

Each university was asked the same basic questions. The discussion is based on the answers to these questions.

Research Policy

The first question asked was:

"What is your official policy relative to staff loads and time allocation for

* The opinions expressed in this paper are the author's and do not necessarily represent the views of the National Science Foundation. The data presented are not to be construed as official statistics of the Foundation.

† By key persons is meant the Dean of Engineering, Director of Engineering Research, the Graduate Dean or a cognizant Department Head.

staff research? In brief, how do you encourage your staff to engage in research?" The purpose of this question was to set the stage for the more specific questions which followed.

The responses to this question fell into three general categories.

Category (1): There was a rather small number of institutions in which the climate for research was quite unfavorable. Several institutions of this group stated that they were not interested in having their staffs do research. The number of institutions which fell into this category was 14 or 10.1% of the 139. This group is designated as (A) in Table I.

Category (2): The next and largest group of institutions is the one where there was some interest in research but the amount of funds for research support was so limited that the research potential of the institution was badly handicapped. Seventy of the 139 institutions or 50.4% fell into this category.

TABLE I

ENGINEERING SCIENCES RESEARCH SUPPORT BY INSTITUTION

Classification of Institution	Number of Institutions	Per Cent
(A) The attitude of the administration is unfavorable to staff research in the engineering sciences.	14	10.1
(B) The administration gives *passive* support to research in the engineering sciences but no attempt is made to provide funds for staff research from ordinary university sources. All research support must come from outside support such as government or industrial contracts.	31	22.3
(C) The administration gives *moderate* support to research in the engineering sciences. In general teaching loads are 12 or more hours per week with only a minimum number of staff members permitted to have a reduction of load to conduct research on regular university funds. In most cases supervision of graduate thesis is counted as an overload.	39	28.1
(D) The administration gives *active* support to research in the engineering sciences. In general teaching loads are 12 hours or less per week with a moderate number of staff members permitted to have a reduction of load to conduct research on regular university funds. In most cases supervision of graduate theses is counted as part of the teaching load.	29	20.8
(E) The administration expects the staff to contribute to the advancement of knowledge through research or other scholarly work. The teaching load is held to 6 to 9 hours with graduate work given equal or greater value in equating the teaching load than undergraduate courses.	26	18.7
Total	139*	100.0

* There are 149 institutions which have one or more undergraduate curricula accredited by the E.C.P.D. No reply was received from 8 of these institutions, the other two are service academies and were excluded from this study.

However, only 31 of the 70 institutions had no funds for research purposes (designated as (B) in Table I) while the other 39 had some limited research funds (designated as (C) in Table I). Those which had some limited research funds could, in rare cases, lower the teaching load of a particular staff member who wished to conduct research. The greatest deterrent against research accomplishment in this group of institutions was heavy teaching loads. As a result the staff members did not have time to do research, and there were insufficient funds to allow them specific research time. The mere reduction of teaching load would not of itself insure research productivity. Of equal importance was the fact that the annual salary was so low that the staff members had to seek gainful occupation during the summers, usually off campus. None of these institutions had funds for the payment of additional salary to the staff during the summer when the staff was available for research work.

Category (3): The third group of institutions, 55 in all, had climates and administrative support which actively *favored* research by the staff. In these institutions it was recognized that research as well as teaching was an obligation of the institution. However, 29 of the 55 institutions were so cramped for funds that they could not insist that the staffs do research or some professional activity other than teaching. All these institutions had some funds available for reduction of teaching loads during the academic year; however, the additional salary of the staff member during the summer months must be provided from other than university funds (designated as (D) in Table I). Only 26 institutions indicated that they *expected* the staff to do some research or other professional work without additional compensation. This group kept the teaching loads low enough so that research work could be done without making any special concessions (designated as (E) in Table I).

In most of these latter institutions, the salary scale was high enough so that the staff members were not forced to find some other means of livelihood during the summer months in order to make a sufficiently large annual wage to live. Only one institution, however, went so far as to state that all of its staff members who were interested could do research without getting any funds outside the regular university sources. Contracts or grants for research from Federal sources would be considered outside the regular university sources. (Table I summarizes this information.)

Since a doctoral degree in engineering is usually considered a research degree, an attempt has been made to check the validity of the answers received to question one (and consequently the validity of the conclusions that will have to be made on the answers to the other questions). This was accomplished by comparing the answers received from the institutions with the data on advanced degrees awarded by the same institution. The latter information was obtained from the Office of Education.* Table II indicates that there is a direct correlation between the doctoral degrees granted by institutions and the research interest of the administration and staff of those institutions. If the institutions from which no replies were received are omitted from the calculation, and tabulation is made on the basis of the 139 replies, 73.4% (419 out of 571) of the doctoral degrees were awarded by the 24 or 17.3% of the institutions which have the most favorable research atmosphere. If the two top brackets of research atmosphere are considered together as satisfactory for research, then 86.5% of the doctoral degrees (493 out of 571) were awarded by 38 institutions or 27.3% of the accredited engineering institutions from whom a reply was obtained.

While these facts are encouraging, it is disturbing to note that 13.5% of the doctoral degrees were awarded in institutions where the research atmosphere can be con-

* Circular No. 64, "Engineering Enrollments and Degrees," 1952, Office of Education, Robert C. Story and Henry H. Armsby.

TABLE II

RELATION BETWEEN ADVANCED DEGREES IN ENGINEERING AND RESEARCH SUPPORT BY THE INSTITUTION TYPE*

Type of Research Support (See Table I)	Doctoral Awards 1951-52		Number of Institutions Awarding Doctoral Degree	Number of Institutions Awarding Master's Degree Only	Number of Institutions Awarding No Graduate Degree	Total E.C.P.D. Accredited Institutions
	Number	Per Cent				
(A)	1	0.2	1	5	8	14
(B)	25	4.3	6	20	5	31
(C)	52	8.9	20	15	4	39
(D)	74	12.6	14	11	4	29
(E)	419	71.5	24	2	0	26
No Reply	15	2.5	2	4***	4**	10
Totals	586	100.0	67	57***	25**	149

* These data obtained from "Engineering Enrollments and Degrees," Circular No. 364, Office of Education.

** Includes one service academy, U. S. Coast Guard Academy.

*** Includes one service academy, U. S. Naval Postgraduate School.

sidered unsatisfactory. In order for the staff to supervise doctoral dissertations and doctoral candidates' research in these institutions, it is necessary for them to carry this work as an overload above the ordinary teaching load at the institution, or additional funds must be obtained (usually by contract on a year to year basis from some Federal agency) to support the research program including a portion of the staff member's salary. This is not a healthy condition for either the student or the staff member. If a doctoral program is to be meaningful it must operate in an atmosphere favorable to research.

While the actual number of degrees granted by these institutions represents only 13.5% (78 of the 571 degrees), the number of institutions professing to offer the doctoral degree in which the research atmosphere is unsatisfactory is quite large. In fact, from the replies received, a total of 65 institutions indicated that they offered the doctoral degree in one or more areas of engineering. Of these 65 institutions only 38 or 58.5% fell in the category of maintaining a research atmosphere which is conducive to long-term basic research, whereas 27 of the institutions or 41.5% were in the unsatisfactory or only passive research support area. While the better research atmosphere institutions are able to handle the present load of Ph.D. candidates, it is probable that this condition will not exist in the near future when the number of Ph.D. candidates will increase. It therefore becomes increasingly important that more institutions in categories (B) and (C) as indicated in Table I improve their situation so that they can offer the doctoral degree under satisfactory research conditions.

It is therefore evident from the answers to question one, "What is your official policy relative to staff loads and time allocation for staff research?", that there is high correlation between a satisfactory research atmosphere and the number of Ph.D. degrees granted. The 24 institutions in which the support of research was greatest and in which the research atmosphere was best, granted over 70% of the doctoral degrees. If the additional 14 institutions are included whose research atmosphere is good, the total percentage of doctoral degrees granted under reasonably satisfactory conditions exceeds 86%.

While less than 14% of the degrees granted were at institutions where the research atmosphere and research support were unsatisfactory, this represented 27 of the doctoral degree-granting institutions or 41.5% of the number of institutions. This situation needs careful attention for its future implication. It is essential that more universities recognize that they have an obligation to support research as well as to teach undergraduate courses.

Type of Research

The second question asked was "Do you believe that both 'applied' and 'basic or fundamental' research should be conducted in your college? Do you have an opinion as to the relative percentages of the two types that you would like to see in your institution? How near are you to that goal?" As might be expected, there was considerable difference of opinion on the specific definitions of "applied" and "basic or fundamental" research. In order not to cloud the issue on the answers to this question, each person was asked to answer the question in the light of his own definition of applied and basic or fundamental research. Therefore, the standards for the answer may vary somewhat from institution to institution.

There was almost unanimous agreement, regardless of definition, that an engineering college should do both "applied" and "basic or fundamental" research in the engineering sciences. The only exceptions were some of the group (A) institutions (see Table I) which either had no opinion on research or did not believe that any research should be conducted in the engineering college. On the other end of the spectrum one of the Group E institutions stated that the research should be 100% "basic or fundamental" research.

The preferred percentage of basic research varied from 20 to 90% with an average value of 55%. However, the value of 50% appeared more frequently than other percentages. (See Table III.) The desirable split at any one institution will depend on the interests of the individual staff members.

The answers were tabulated in accordance with the type institutions (Types A, B, C, D, and E), to see if there was a significant trend in the percentages favored depending on the research atmosphere of the institution. As shown in Table II, there does not appear to be any significant trend and it can generally be said that engineering educators believe that a significant amount of both applied and basic research in the engineering sciences should be in operation in the various engineering colleges throughout the country. The reasons given varied considerably but the one mentioned more than any other is the fact that engineering is in effect an applied science. While there was agreement that advances in engineering in the future will be stifled unless more basic research in the engineering sciences is conducted, there was also agreement that basic research must not be done to the exclusion of applied research. The students in the engineering colleges should come in contact with the philosophy of both types of research. The relative ratios of the two which are in operation at any particular institution at a specific time will depend on a variety of factors such as the interest of the staff members, the nature of the problems in which the staff is interested and the location of the institution with respect to

TABLE III

DESIRABILITY OF BOTH APPLIED AND BASIC RESEARCH IN THE ENGINEERING SCIENCES AT UNIVERSITIES

Type Institution	Number of Institutions	% Applied	% Basic
Average of all answers	139	45	55
Type E	26	40	60
Type D	29	48	52
Type C	39	43	57
Type B	31	48	52
Type A	14	42	58

types of industry and natural resources of the area.

Except for institutions in the Type E classification, there was general agreement that more applied research was now in operation in the universities than appeared desirable. The general reason given was that money for the support of applied research was much easier to obtain and, therefore, it was better to do the applied research than no research at all. The deviation from the goal of approximately 55% basic research and 45% applied research in the engineering sciences varies widely and is greatest in those institutions which do not offer the Ph.D. degree.

Staff Availability

The third question asked was as follows:

"Approximately how many members of your present staff would be interested in conducting 'basic' research in one of the engineering sciences if funds from a National Science Foundation grant or other source were available? (Indicate separately staff members not now engaged in research for lack of funds and those who might drop 'applied' research in favor of basic research if funds are available.)"

In considering the answers given to the first part of this question, that is those staff members now engaged in research for lack of funds, the answers fell into two general categories: (a) those who were doing comparatively little or no research largely for lack of funds or inability on the part of the institution to allow time for research without outside funds, and (b) those staff members who were doing a moderate amount of research, but who could do further basic research without overloading themselves. In order to obtain a proper perspective, the availability of persons should be considered in relation to the institution by whom they were employed.

In the B and C Type institutions, most of those who would like to do basic research and were not doing it, gave the prime reason as lack of funds. In the D and E Type institutions, more staff members usually had some research support but indicated that they could conduct additional research without an undue overload if funds were available. One other point should be stressed and that is the uneven distribution of research funds by the various disciplines within the engineering sciences. The number of staff members immediately available for basic research if grant support were available is quite limited in the fields of electronics, metallurgy and aeronautics. These are the three fields in which the major concentration of funds has come from the Department of Defense. On the other hand, there has been much less emphasis from the Department of Defense on basic research in the fields of chemical engineering, civil engineering and mechanical engineering. Therefore, there is available immediately a larger number of staff members in these areas.

Table IV summarizes the availability of persons to do basic research by types of institutions in which they are employed.

The second part of the question, asking about, "those who might drop 'applied research' in favor of basic research if funds were available," shows a somewhat different pattern. From the answers to this question, it is evident that while

TABLE IV

STAFF MEMBERS IMMEDIATELY AVAILABLE FOR BASIC RESEARCH IN THE ENGINEERING SCIENCES IF GRANT SUPPORT IS AVAILABLE

Institutions			Research Staff Available	
Type Institution	Number	Per Cent	Number of Men	Per Cent
A	14	10.1	4	0.9
B	31	22.3	58	13.0
C	39	28.1	117	26.3
D	29	20.8	87	19.5
E	26	18.7	177	40.3
Total	139	100.0	443	100.0

many staff members are kept busy with as heavy a research load as they can handle, these staff members are not entirely happy with the type of research support which they have been receiving. While many of these research programs intend to be of the basic type, the mere fact that support is coming from an agency which has a specific mission to accomplish, other than the research, tends to slant the direction which the research takes.

In comparing Table V with Table IV, as might be expected, a rather substantial number of persons now doing research and employed in Type E institutions would like to shift their research more towards the basic end of the spectrum. They would prefer that support would come from a source that had research as its primary aim, so that there would be less tendency to slant the program toward a specific objective.

One other fact seems to be evident from the answers to this question. If the B and C Type institutions are to engage in a comprehensive research program, they must acquire a larger number of staff members who would be interested in doing basic research. For example, from Table V, the Type E institutions represent only 18.7% of the engineering institutions, but they have on their staff 43.3% of the persons who are interested in doing basic research, whereas the B Type institutions represent 22.3% of the total engineering institutions but have on their staffs only 13.6% of the persons who are interested in doing basic research. Contrary to expectations this discrepancy cannot be explained on the basis of student load either at the graduate or undergraduate level. The 31 B type institutions have an average of about 900 undergraduate students and 145 graduate students, whereas the 26 E type have an average of 1300 undergraduate and 260 graduate students. The research atmosphere at an institution can be fostered by a sympathetic administration and careful selection of staff. This is possible despite higher than desirable teaching loads.

TABLE V

TOTAL STAFF MEMBERS WHO WOULD PREFER TO DO BASIC RESEARCH IN THE ENGINEERING SCIENCES IF GRANT SUPPORT WERE AVAILABLE

Institutions			Research Personnel	
Type Institution	Number	Per Cent	Number of Men	Per Cent
A	14	10.1	43	2.2
B	31	22.3	266	13.6
C	39	28.1	409	20.9
D	29	20.8	390	20.0
E	26	18.7	846	43.3
Total	139	100.0	1954	100.00

As a check on the validity of the figures in Tables IV and V, an estimate by a different procedure has been made of the number of staff members who might do basic research. It is estimated that there are about 9000 * engineering educators in the United States. On the average staff about 50% will be interested in doing research of any kind. Of those interested in engaging in research, 55% (see Table III) will be interested in basic research at any one time. This would indicate that about 2500 staff members in engineering might need support for basic research. Almost 2000 of these persons have been located (see Table V). The additional persons are at the eight accredited institutions which did not reply to this survey and at the 45 institutions offering engineering but whose undergraduate courses are not accredited.

Graduate Students

The next question was worded as follows: "Since the manpower situation is quite serious, in regard to engineering students with advanced degrees, how many new graduate students, either at the M.S. level or the Ph.D. level, could be supported and encouraged to obtain their

* Educational Directory, The University of Chicago Press, January 15, 1953.

advanced degrees through the research mentioned above?"

As might be expected from the answers to the previous questions, there was some variation due to the type of institutions, The type A institutions had little interest in graduate work and would provide few additional graduate students. The number of additional graduate students that could be supported is almost directly proportional to the staff members interested in research at all the other institutions. While there was some tendency for the institutions of the (D) and (E) types to handle a slightly larger number of graduate students per staff member than at the (B) and (C) types, the number is probably not statistically meaningful. For all practical purposes it can be said that on the average there would be 1.5 additional graduate students per staff member who received grant support for basic research.

Therefore, somewhat more than 600 additional graduate students could be trained immediately by the somewhat more than 400 staff members who are presently available to do basic research. If other staff members could be relieved of a portion of their applied research and were given support to do basic research, more than 2700 additional graduate students could have their research supervised by the 1900-odd staff members who would become available.

TABLE VI

ADDITIONAL GRADUATE STUDENTS WHO COULD BE SUPPORTED BY GRANTS

Type Institution	Staff Available Immediately	Graduate Students Immediately	Future Staff Available*	Future Graduate Students*
A	4	4	43	43
B	58	58	266	266
C	117	164	409	573
D	87	128	390	574
E	177	273	846	1311
Total	443	627	1954	2767

* These columns are based on the assumption that staff now engaged on applied research could replace part of that support with basic research support.

TABLE VII

TYPICAL GRANT

(Items in order of importance to the institution)

Item	
1. Staff Salary (mainly summers)	$1600
2. Graduate Assistants (1½)	3300
3. Permanent Equipment	1000
4. Expendable Equipment, Supplies, Travel, etc.	1000
5. Indirect costs @15% of total (approx.)	1000
Total	$7900

During the year 1951–52 the 149 institutions having one or more curricula accredited by the E.C.P.D. conferred 27,155 * bachelors or first degrees. At the same time there were conferred 4132 masters degrees and 586 doctors degrees.

The consensus of opinion of those to whom the author has raised the question is that there is need for 20 masters degree and 5 doctors degree people for each 100 bachelors degrees in engineering subjects. If this is true, then the graduate schools are supplying only 80% of the masters degree people and less than 50% of the doctors degree people needed on the basis of the present graduating classes.

If *2700* graduate students were supported by the research grant program mentioned above, a big step forward would be taken towards filling the gap. When students are supported by grants, they can expect to earn the masters degree in from 1 calendar year to 15 months, whereas, at the present time, the enrollment of 17,418 graduate students produces only 4132 masters degrees per year, or almost 4 years to earn a masters degree. This is due to the fact that the majority of the graduate students are enrolled in night courses and are employed full-time † during the day. Thus

* J. Eng. E. *43*, 4 (1953).

† Op. cit.

they can do only a limited amount of graduate study each year.

On the assumption that a 1-year grant will produce 1 masters degree, a 3-year grant will produce 1 doctors degree and that a ratio of masters degrees to doctors degrees of 4 to 1 is desirable, the research program mentioned above could produce 1500 persons with masters degrees per year and 400 persons with doctors degrees per year. This would be the annual increase per year and would go a long way towards filling the needs.

Research Support

Having now determined the needs for staff support of basic research and the number of additional advanced degree engineers that could be produced, the next question was directed towards the cost of the program. The fifth question asked was, "In round numbers, how much additional money (above that presently available to you) is needed to support such a research program at your institution? In making your estimates on this matter, it is assumed that in order to activate the program, you would not hire additional staff members other than technical assistants or the graduate students mentioned above. It could be assumed that the grant might support, during the summer months, those members of the staff who are on a nine or ten months basis so that the research program could have continuity."

The replies to this question were surprisingly consistent with the variations predictable on the type of the institutions (A, B, C, D, or E as noted in Table I). There is almost unaminous agreement that the first and most pressing need is for the payment of staff salaries during the summer months. Many staff members would like to do basic research but the necessity to earn additional income during the summer forces them to either (a) take off-campus employment during the summer months or (b) do applied research on campus.

Only the D and E type institutions are able to give the staff low enough teaching loads so that basic research can be done during the academic year without charging a portion of the principal investigator's salary to the grant. The C type institutions, in limited cases, may be able to allow the staff time for basic research but in most cases must charge a proportionate share of the principal investigator's salary to the grant in order to hire additional personnel to carry the teaching load.

The second greatest need for support on the grant is assistance to the principal investigator in the form of graduate students. Most of the institutions had unfilled graduate assistantships of various types which could not be filled because the salary was too low. There was unanimity of opinion that more graduate students could be obtained by raising the value of graduate research assistantships, but there was considerable variation of opinion on the amount.

The best estimate of the needs to encourage the required number of graduate students in engineering is based on a series of discussions coupled with the formal answers to the questions. It is based on the fact that (a) the ratio of earnings of the new bachelors degree man to his earnings as a graduate assistant must approximate the ratio that existed just prior to World War II and (b) the amount that the graduate student receives on a 12 months basis this year should equal in purchasing power the amount that he would have received at that time. These two lines of reasoning equate to a minimum 12 months pay for a graduate research assistant as varying from $2000 to $2400.

Using these figures as a base and adding the fact that the student would be working on a research problem that would be acceptable to the graduate school for degree purposes, there is overwhelming agreement that the desired number of qualified graduate students could be obtained in the various day school graduate curricula. The average grant request

would be for support of one and a half such graduate students.

The item mentioned as third in importance was permanent equipment. On the average that amounted to $1000 per grant per year.

The fourth item is a catch-all covering expendable equipment, supplies, travel and other miscellaneous items. These totalled about $1000.

When the items are totalled and 15% is added for indirect costs the amount is approximately $8000 per grant per year. (See Table VII for breakdown.)

From this analysis it now appears reasonable to state two figures for the support of basic research in the engineering sciences.

The first figure is an amount that is needed for the support of basic research immediately. It would go to the support of the approximately 437 staff members (see Table IV) who do not have research support at this time. If each of these persons was to receive the average grant of $8000, the total needed for the basic research support in the engineering sciences is $3,500,000. This sum is predicated on the fact that there would be no reduction in research support by other agencies, either governmental or industrial.

If there were a reduction in applied research support and support were given to all the engineering staff members who would like to do basic research, the number is approximately 2000 people (Table V figure accounts for 1954) requiring $16,000,000. This figure is predicated on allowing 1 average grant for each person capable of doing basic research in the engineering sciences with the universities supplying all the additional funds from their normal sources.

Summary

The most striking factor which this survey brings to light is that an insufficient number of engineering colleges recognize their responsibility towards research and the advancement of knowledge. A sound doctoral program is dependent on a favorable research climate. Over 40% of the Ph.D. degree granting institutions had insufficient funds to justify such a program without resorting to staff overloads or contract research support for the staff.

Research in engineering colleges should be divided between basic and applied research. A ratio of approximately one to one in the two types appears to be the most desirable situation.

In order to assist more staff members to do basic research, funds are needed to pay additional staff salaries during the summer months. This requires a sum equal to about 25% of the present academic salary for those persons.

To increase the number of graduate students in engineering, funds must be available. It is estimated that between $2000 and $2400 per graduate student is needed for their support. On the basis of staff members now on the staffs of the universities, about 2700 additional graduate students could be educated with present facilities.

On The Role of Physics in Engineering Education?

By R. J. SEEGER

Assistant Director, National Science Foundation

Since the organization of the American Society for Engineering Education in 1893, there have been many studies of engineering curricula, such as the Mann Report (Carnegie Bulletin No. 11), the Wickenden Report of 1923 (said to be "monumental"), the "Aims and Scope of Engineering Curricula" (1940), "Engineering Education after the War" (1944), and Jackson's "Present Status and Trends of Engineering Education in the United States" (1939, essentially a "supplement to the Wickenden Report").

The present ASEE Committee on Evaluation of Engineering Education proposed 34 searching questions at its Chicago meeting in September 1952, and suggested these as items for discussion by Institutional Committees. A group of these questions dealt with the curricular content and its relation to the objectives of engineering education. Among the 53 reports submitted by Institutional Committees, there is general agreement that research in physics has been constantly expanding the available knowledge in this field and that any current revision of engineering curricula must of necessity involve consideration of the inclusion of this new material into the already overcrowded physics courses. Some provocative excerpts from these reports are cited below with respect to physics.

Provocative Excerpts

"The injection of recent scientific advances in undergraduate curricula will prompt thinking along the lines of a five-year program." "Additional mathematics and physics fundamental to particular departments must be added in the time available." New material must "be crowded into the present curriculum by reducing empiricism, by a more fundamental presentation of subject matter, and by integrated study of various fields." "Nuclear physics, some aspects of biochemistry, statistics, topology and nomography will be translated into engineering practice within 25 years. The fundamentals could conceivably be substituted for other topics now taught." "Atomic and nuclear physics should include the structure of the nucleus, radiation and its detection, nuclear fission and power, mass spectroscopy, wave motion, low temperature, high vacuum effects and ultrasonic spectroscopy." "Sophomore physics should be modified by de-emphasizing mechanics, electricity and heat, and substituting modern physics in place of these." "A vote of one engineering faculty showed 62% favoring the introduction of nuclear physics in the present undergraduate curricula." "Duplication of course content can be minimized by de-emphasizing such topics as mechanics, electricity and heat in physics." "Sophomore physics should be altered by eliminating mechanics, heat and electricity and increasing the time for light, sound and nuclear physics." "Many engineering service courses are designed for students majoring in a particular field by instructors with no interest in or knowledge of the student's background." "About 60% of one faculty voted in favor of requiring

thermodynamics, heat transfer, electrical circuits and fields, electronics, differential equations and nuclear physics for all engineers." One local committee proposes "that all of sophomore physics be deleted and taught as separate subjects in the engineering science division. These would include mechanics, thermodynamics, electricity, light and sound."

At the Gainesville meeting of the Main Committee in June 1953, two subcommittees were appointed to consider certain questions involving curricula. Excerpts from tentative drafts of their reports are given below with reference to physics.

Excerpts from Sub-Committee Reports

"Much fundamental research in what is now called the engineering sciences was then being conducted by physicists. Since 1940 nearly all research physicists have had their interests reoriented toward nuclear problems and it seems doubtful that this interest will be adequately returned to the fields of vibrations, elasticity, plasticity, heat transfer, engineering thermodynamics, fluid flow, electronics and the other background sciences of engineering. Hence *engineers have become responsible for the continued research in all the fields of engineering science.*" *"The first four years of the undergraduate program can hardly be identical any longer for these two types of engineering education which in this report will be called professional-general and professional-scientific.*" One engineer has defined engineering science as those portions of physics, chemistry, and mathematics that are no longer of interest to research physicists, chemists, and mathematicians. "The very nature of the full background is such as to call for graduate studies in the engineering sciences."

Under the curricular content recommended for *professional-scientific* accreditation one finds: "Physics—including an introduction to modern and nuclear physics and inluding that of the solid state, but excluding mechanics, electricity and heat from the elementary course if this material is adequately covered elsewhere."

Under the curricular content for *professional-general* accreditation one finds: "Physics—general physics and such topics of modern physics as may be appropriate to the curriculum, but excluding mechanics, electricity and heat if these are covered adequately elsewhere." "Past experience would lead us to predict with reasonable assurance that the new developments in atomic, nuclear, and solid state physics . . . will become the center of rapidly and developing areas of engineering practice in the years ahead."

"Physics as taught for engineers has undergone only minor changes during the past generation in which many revolutionary new concepts have been developed that are influencing engineering practice. Modern physics, including nuclear and solid state physics, should be included in undergraduate curricula. It is felt that duplication between physics and statics, dynamics, thermodynamics, and electricity should be reduced or eliminated to provide time for basic study of modern physics. The study of acoustics and optics is considered desirable rather than essential so that its consumption of time should be small."

Increase Efficiency

"There is the possibility of increasing the efficiency of instruction or of eliminating some of the existing course content. Several of the Institutional Committees have discussed the excessive duplication existing between both the material covered in mathematics, physics, and mechanics, and between the material covered in these basic courses and that covered in advanced engineering courses. It is not uncommon to hear remarks regarding the inability of students to learn the fundamentals of electricity in physics, and of their having to start all over again in electrical engineering. Similar remarks involve mechanics and mathematics, and college mathematics and high school mathematics. There is doubtless some truth in these statements but many times the problem is deeper and frequently is a result of lack

of coordination and exchange of information among departments."

"Perhaps a more serious loss in efficiency of instruction occurs because of the lack of motivation of students in the basic courses. This lack of motivation is recognized both by mathematics, physics and chemistry teachers, and by the engineering staff. It might be possible to improve this situation by inaugurating a single consolidated series of courses comprising the basic material in mathematics, physics, chemistry, mechanics and thermodynamics in the first five of six semesters. It would be taught in the engineering college to provide real motivation to the assignment of strong engineering applications. Accompanying laboratory work should consist of engineering experiments and not classical experiments in physics and chemistry. Such a series of courses should develop leadership and initiative in the students. Engineering reports, including drawings, should be prepared, and nomographic charts, elementary statistical analyses and basic measurements and measuring instruments should be studied and utilized. Since such a set of courses should require considerably less time than the conventional arrangement, it would be possible to offer advanced courses in modern physics, chemistry and mathematics in the last year of the curriculum. These courses would be taught by the staff members in the special fields. The material would then be presented to more mature students better able to appreciate the presentation by specialists in these respective fields."

"It must be emphasized again that each school should find its own solution to the problem of increased demands. The Committee feels that the added requirements can be met within the present time framework simply by increasing the efficiency of instruction and of curriculum organization. Successful professional engineers in the industrial field depend upon increased efficiency for success, and a professional engineer in education should be no exception."

Physics Committees

At its Baton Rouge meeting in February 1953, the ASEE Committee on the Evaluation of Engineering Education appointed a Physics Subcommittee consisting of E. Weber (electrical engineering, Brooklyn Polytechnic Institute), Chairman; A. P. Colburn (chemical engineering, University of Delaware); and R. J. Seeger (physics, National Science Foundation). This Subcommittee's report was adopted by the Main Committee in Gainesville in June 1953. It recommended that certain questions be referred to the ASEE Physics Division and certain other questions to the AAPT. In the ASEE Physics Division, the matter was referred to its Executive Committee consisting of R. J. Seeger (Chairman, National Science Foundation), C. E. Bennett (University of Maine), G. P. Brewington (Lawrence Institute of Technology), G. Burnham (Norwich University), J. R. Dunning (Columbia University), E. Hutchisson (Case Institute of Technology), D. H. Loughridge (Northwestern University) and J. G. Potter (A. & M. College of Texas). In the AAPT, the matter was referred to its Committee on Engineering Education: J. H. Keenan (Chairman, M.I.T.), C. E. Bennett (University of Maine), O. W. Eshbach (Northwestern University), W. C. Kelly (University of Pittsburgh) and J. G. Potter (A. & M. College of Texas). These committees met jointly with the Physics Subcommittee of the Main Committee and A. Bronwell, Secretary of ASEE, at the American Institute of Physics in October 1953.

More Widespread Discussion Needed

These committees recommended unanimously that no action be taken by the ASEE until there has been more widespread discussion of the problem among physicists and engineers. In order to insure more widespread knowledge, they recommended that an article be written for *Physics Today* to give physicists immediately some advance information about the

problems at hand. Finally, these committees recommended early institutional discussions and national symposia, as well as curricula conferences by small groups representing various points of view.

It is evident that engineers and physicists must both answer the questions: What contributions *can* physicists make to engineering education? What contributions *should* physicists make to engineering education? In short, what is the role of physics in engineering education?

College Notes

The University of Pennsylvania has announced the elevation of Dr. Carl C. Chambers, Dean of the University's Moore School of Electrical Engineering, to Vice-President in Charge of Engineering Affairs. He will direct the University's educational activities in chemical, civil, electrical, mechanical and metallurgical engineering.

• • •

Nils Yngve Wessell was installed on December 9, 1953 as President of **Tufts College.**

• • •

L. V. Bewley, head of the department of electrical engineering at **Lehigh University,** has been named dean of the college of engineering at that school.

• • •

R. S. Green has been named executive director of the Engineering Experiment Station at the **Ohio State University.**

• • •

The Eighth Annual Industry-Faculty Conference will be held at **Louisiana State University** on April 6–7, 1954. The theme for the conference will be "Education and Industry."

• • •

Edward McHugh has been appointed dean of engineering at **Clarkson College of Technology.**

Let's Look at the Causes for the Professional Collective Bargaining Groups

By T. H. EVANS

Dean of Engineering, Colorado A. & M. College

The paper by Dean Woolrich on The Professional Engineer, in the April issue of our journal, I believe, is an unusually capable, sincere, and intelligent attempt to review the situation within our profession today. This is an effort to discuss some of the points he raised and perhaps to try to visualize more of the other side of the picture, to which the writer has devoted some study.

"Unionism" has a rather sinister connotation to many of us because of actions of the labor unions over the years. It can mean violence, lack of the public interest at times, getting all that the traffic will bear, diminution of productive effort, equating all in the union to a common level irregardless of merit. In other words, a goal of increased reward for increased mediocrity.

The word "union" also can mean something fine. Our forefathers created a Union, and for its preservation many of our fellow countrymen have died. Therefore it is not clear why we must assume that a much higher level group of professionals is bound to follow the labor union line simply because they have banded together to act collectively with their employers, or because they bear the sometimes unfortunate name, "union." It is believed to be the word alone which has apparently colored the thinking of many professional people and caused a prejudgment against these groups before they have had a chance to act in any way —either professionally or unprofessionally. It does not seem logical to assume that a professional engineer will act like a professional because be belongs to an engineering society, but like a typical labor unionist if he also belongs to a professional bargaining group. From what the writer can learn about most of these groups they have no intention of following the pattern set by the labor unions. Their objective is to deal with management on a rational, fair, cooperative, ethical, and professional level. Most of them appear to realize that they have a critical stake in the progress of industry, just as the latter should have in the welfare of engineer employees. They seem to have no intention of trying to bleed industry of all its profit. They are trying merely to get industry ot recognize the proper economic level for the engineer (and particularly the engineer with five or more years' experience behind him). Nor is there to be a "levelling off," as is typical of labor unions. These engineering associations have advocated categories within an industry depending on ability, experience, and other factors; which is similar in objective to those our national societies have published from time to time, showing different grades of engineering ability, and even advocating ranges of salary in some instances. It should be emphasized that the Engineers and Scientists of America is merely a national federation and that each member unit would still handle its own employer-employee relationships. Therefore the numbers involved would not be so great that an individual would be lost sight of. And although the basic reason for forming these groups is the feeling of a need for eco-

nomic improvement, only because the profession has not helped them in this respect, their other principal objectives are professional and social improvement for the engineering employee. Many of these same points were brought out at the ASEE meeting in June 1949.

Where there is so much smoke there must be some fire. Something is radically wrong in our profession when a group such as ESA can spring up almost overnight with a strength comparable to any one of our individual engineering societies. Many of us don't feel we can arbitrarily condemn such groups, which are fighting for individual rights, when they honestly believe they need collective help. A large number of these individuals wanted their profession to help. It could not because it was fragmented and had no real power. Nor has the recent attempt to insist on Plan A for unity, rather than a more democratic and more universally acceptable plan, helped make those already dissatisfied feel that the profession was sincerely interested in the welfare of the engineer as an individual. Until the profession could show real interest in, and intent to help, engineers in *all* aspects of their professional life, it is difficult to see how these engineers forming the bargaining units could be expected to do otherwise.

Industry Has Been Negligent

As Dean Woolrich points out, industry has obviously been negligent in setting up proper scales of advancement for engineers with several years of experience. Is industry in general going to assume the responsibility to correct these inequities? The disunited Engineering profession has been unable to do anything about it. So what is left to an individual with any backbone? When a conserative group like the engineers flares up in many localities there must be some good reason for it.

The real kernel of the difficulty may be the apparent inability of the autonomous groups making up the Engineering profession to give a little in order to bring about what is best for the whole. From comments all around the country it seems apparent that the bulk of the membership of the engineering societies are far from being preponderantly in favor of Plan A, even though it is the one now being put into effect. There is at least one Section of ASEE which is almost unanimously in favor of some plan more akin to C than A. If a democratic survey of individual professional engineers throughout the country was made (or even just among those in the societies) the great majority would apparently be in favor of Plan C, or some plan similar to it, such as that proposed by the GE Engineers Association in Electrical Engineering for April 1953.

We thus have a tug of war between certain powers in the technical societies, the NSPE, and now the ESA. One possible solution is for the rank and file of the profession to insist on immediate and truly acceptable Unity, *coupled with an additional and definite objective showing some intent to improve where necessary the economic welfare of engineering employees* based on their achievements and contributions to industry. It is believed these two moves would eliminate the basic cause of the unrest and dissatisfaction within our profession. If this were done quickly then the need for any local "bargaining" would be nullified. Many local sections of the national societies are requesting their Boards of Direction to do this.

Defense Measure

Some of us feel that the engineering collective bargaining groups are a defense measure, used in desperation when no other help was available; and if the Engineering profession was truly unified, as is the Medical profession, then it could give the employed engineer the help he presently feels only the bargaining groups can give him. The writer will be disappointed badly, and clamor as loudly for their scalps as anyone, if these groups in general lower themselves to the unethical and unprofessional tactics of the labor

unions. Since the profession is not giving adequate support to the individual professionally and economically, however, one can't honestly condemn these bargaining groups for trying to pull the iron out of the fire, if they maintain their ethical and professional standards. Naturally we must be concerned about the strength and growth of the collective bargaining movement, but if we can't offer something as good or better then it seems unreasonable to condemn such groups, especially if they prove to be truly professional. Condemnation only raises a smoke screen to cover the ineffectiveness of our profession as such. Major surgery to get at the fundamental causes of our disunity is needed, and not some expedient measure that will create further disunity. The truly scientific way is to analyze the entire problem objectively for basic causes, and it does not seem that such has been done fully. This paper is a meager attempt to try to expose a little of the other side, about which we have heard almost nothing. It is no intended as a plea for more collective bargaining units; but it is intended to stress the need for more constructive suggestions to overcome the need for such units. What we must all strive for is *real* Unity, and the time is now.

As engineering educators we have a great stake in this tug of war. We also have an opportunity to do something about it in the local sections of our national societies, and with our students.

College Notes

A short course on High Temperature Properties of Materials will be held at **The Pennsylvania State University** between June 21 to June 25 inclusive. Following this course one on Mechanics of Creep will be conducted between June 28 and July 2. Authorities from industrial, governmental and educational institutions will give the lectures for both these courses. The programs are planned to give a broad coverage of high temperature properties of materials and mechanics of creep by including physical, metallurgical and design aspects of these subjects. For further information, please write Dr. Joseph Marin, Department of Engineering Mechanics, The Pennsylvania State University, State College, Pa

• • •

Two hundred high school science and mathematics teachers from 24 states will spend six weeks of expense-free study next summer under fellowships granted by the **General Electric Company.** The four programs will be operated at Union College, Schenectady, for 50 science teachers; Rensselaer Polytechnic Institute, Troy, N. Y., for 50 mathematics teachers; Case Institute of Technology, Cleveland, O., for 50 physics teachers; and Purdue University, Lafayette, Ind., for 50 mathematics teachers.

Teaching Tips
(A New Feature)

The fundamentals of good teaching are known to nearly all teachers. These include a good knowledge of the subject, adequate preparation for class, clear explanation, student motivation, and a sincere interest in the individual student. "Teaching Tips" are not meant to reemphasize these fundamentals, but rather to provide stimulating suggestions regarding their application to various teaching situations.

Our first "Teaching Tip" is from the Institutional Report of the University of Rochester on Improvement of Teaching. We hope it may suggest an improved technique for doing your own teaching job.

We would like to publish a series of such tips and need your help in finding and reporting them. When you have used effectively a new or different approach to your teaching, it gives a thrill! Won't you share it by sending us a report of it?

FRED H. PUMPHREY
University of Florida
Chairman, Committee on Excerpts from Institutional Reports

A Kinematics Term Report

University of Rochester

A term report in Kinematics is used at the University of Rochester to achieve the following three-fold objective; first, to relate the study of kinematics to everyday experience and to arouse the curiosity of each student; second, to develop an appreciation for the careful design that has gone into the many mechanisms he finds and uses; and third, to develop the habit of a systematic gathering of data to be used as the basis for analysis and design.

In order to obtain the time for this report, the time needed for other phases of instruction were reduced as follows:

a. Teaching films reduced the time needed for lectures.
b. Laboratory or drafting time was reduced by combining two objectives in a single problem.

This arrangement provided two weeks at the end of the course for a term report. The class time was used to review the course, outline what was wanted in the term report, and class discussions that developed from the term report. The study time (amounting to 8 hours per week) was used for writing the report, and the laboratory time (amounting to six hours per week) was used for the preparation of such drawings as were required in the report.

The students were first advised that a term report would be required at the beginning of the course. They were advised not to make a selection of the project until later in the course. At the middle of the term, they were required to select a problem (usually a linkage) on which to report.

They were encouraged to visit local in-

dustries and discuss kinematics linkage problems with them. And finally they were given definite instructions for the selection of a project, the instructor using care to prevent the student from selecting a problem that was either too simple or too complicated.

The report form used is direct. First, there is a careful description of the linkage, its purpose, and any other pertinent material. Second, there is an analysis of the motion, with a formulation (if possible) of the ideal situation. Then there is a comparison of the ideal situation with the actual solution. In this portion of the report the use of instant centers, motion curves, and mathematical relationships are included. Some consideration is also given to power economy.

The third portion of the report is a conclusion. This states how well the purpose of the mechanism is accomplished. If a comparison between various desirable features in the design is involved, the compromise is discussed.

There is always the possibility that some student may stumble onto an improvement.

Project Method is Used in Time and Motion Study Course

University of Rochester

". . . . . The class divides itself into squads of two for laboratory work and each squad works on a project of its own choice. Many of these are in no way related to any of the others but a few each term work as a group of squads in an assembly line type of accomplishment of a task. In the beginning, they make a microanalysis of the performance of the task with the aid of 16 mm movies and sino chart from which they develop a new method using the basic principles of motion and time study as well as those of mechanics, economics, and the other fields. We then open up our wood working, machine shop, electrical and related facilities for them to use as they see fit in demonstrating their ideas.

The instructor plays the part of a supervisor of so many research projects and interferes only to the extent that a good supervisor should. In addition, bull sessions of the type that broaden the base of the education of the student are promoted.

In this way, we

1. teach motion and time study.
2. integrate accomplishment in several fields.
3. develop the concept that many problems must be solved by industry at the same time, in contrast to situation where all members of a class solve the same problem at the same time.
4. provide an outlet for an engineer's desire to use his hands in a physical demonstration of his ideas.
5. help the student evaluate the magnitude of a research project.
6. promote interest in younger men by conducting this interesting work where all see it frequently."

The Final Course*

Dress Rehearsal for Practice

By A. BOYAJIAN

Consulting Engineer
(General Electric Co., retired)

The rapid growth of technology, with the increasing number of specialties, has made many of us sigh with discouragement in our efforts to keep up with the progress of the art. The older engineer has dropped, one after another, many subjects whose literature he used to scan. But schools can not afford to neglect the technical progress. The smaller schools are seriously handicapped, and while the biggest schools can maintain a specialist in each subject, adding more specialties and offering an increasing number of courses each year, yet the student's limited capacity to learn and his inability to forsee into what specialty circumstances will take him later, constitute the real handicap in the big school as well as in the little.

The remedy generally offered for this situation is to *teach fundamentals*—physics and mathematics—and let the student specialize after he goes into industry. This principle is perfectly sound, but a good principle needs also a good embodiment to make it successful. When the fundamentals are taught, it would be wise to make sure that the student will be able to apply those fundamentals. Otherwise, the 4-year college attendance may mean only the learning of engineering theory and not to receiving an engineering *training*. The purpose of this contribution therefore is to indicate (a) concrete objectives and *criteria* for this purpose, and (b) *means* to accomplish it: in other words, a bridge between theory and practice.

Problems

Let us look into the problems that the average graduate of a 4-year "fundamentals" course faces.

1. He most likely will welcome employment by a large employer. Job security is greater with the larger employers, and many of them also have training courses to fit a person into a specialty.

Over the years, these courses have been evolved to fit the technical equipment of the average graduate, and so the scheme should work pretty well, and on the whole it does. And yet our candidate, if ambitious at all, is apt to be dissatisfied with his education. No matter what the group assignment may be, he is likely to be eclipsed by one or another associate who happens to have had a course in the subject. Our man will experience also another trouble that will hurt him much more acutely in the employ of a small employer as follows.

2. The simplest looking problems that arise in practice frequently involve many specialties, including higher mathematics; and while in a large company advice can be had from many specialists, in the small company one generally has to fall back on his own resources. It is general experience that learning a new course by self-help is a very difficult thing compared with learning it in school, and our

* Presented at the Annual Meeting of ASEE, Educational Methods Division, University of Florida, June, 1953.

man is apt to bemoan that he "never had a course in that in school, period," the *period* meaning that that is enough to keep him out of that field unless he goes back to school or an employer offers him a course. This is a most regrettable state of affairs. The attitude of the "fundamentals" graduate should be this, and he should be able to justify it: "I don't know the first thing about that field, but in a few weeks I can tackle at least a minor project in that field." How can he have such self confidence? By having done it in a similar situation before.

3. Depressions are terrible things for those who lose their jobs, and in applying for one job after another, our fundamentals man may face a severe competition from others who appear better prepared. Opportunities are not lacking by any means during depressions, but in each case our man somehow is not qualified to take advantage of them. He is like the speculator who sees many bargains in stocks but has no money (or credit) to buy them. To justify the principle of the "fundamentals" system, our graduate should be capable of doing a little creative planning for himself, and to prepare himself to qualify for a profitable activity.

4. We frequently speak of a "college-trained" person. Would the word "trained" be quite correct for our man? If the college coach does no more than give lectures and written examinations to the team, is that "training" the team? Realistic practice is needed in engineering just as much as in sports. Engineering practice comes after college, except in those schools operated on the Cooperative Plan, but is it not wise, as the college days draw to their close, to make sure with some trial exercises that the graduate will know how to practice when he gets out?

5. Weak motivation is a handicap in education. The average student probably does not know into what field circumstances will force him and what courses will do him the most good. So he studies the prescribed courses to get his diploma and he may even feel that he can afford to forget a number of his courses after he graduates. If the life of a college graduate depended on mastering analytic geometry or first year electronics in two weeks by self help, he surely could do it. Through intensive study, most any one-semester course can be mastered by a graduate of average ability in a few weeks with far less motivation than that, provided that he has had some experience in that direction and really needs it for a purpose. *While still in college, the student must learn how to master a new subject outside of college.*

Realistic Practice

In the light of the foregoing comments, it may be evident that to make a well-rounded graduate of engineering fundamentals, class-room instruction must be supplemented in college, under proper guidance, by sufficient *realistic* practice; and the entire second semester of the last year may well be devoted to this in a systematic program that may be called *Introduction to Engineering Practice.* This may comprise, let us say, at least four practical projects in different fields, each requiring four to six weeks concentrated labor, including the following activities.

1. During the first week or two, the student must study intensively by himself (consulting any one he wishes) the theory of the field of his project—electronics, hydraulics, communication, air-conditioning, illumination, etc. To make this speed possible, a project must open with an orientation lecture (of probably two hours) giving the student an idea of the things that the project involves, and a carefully selected list of the most helpful books and other references to study. The student must be carefully protected from bibliographies that are burdened with heterogenous, irrelevant and unintelligible items. Good books are so few, and good articles fewer yet. The student's time must be conserved by guiding him to the most helpful ones.

2. Then comes field surveys or laboratory experiments to secure the data on which he will base his decisions. For instance, if the project is the design of an air-conditioning system for a particular hospital, a survey of that hospital's needs has to be made. (Of course the original architect's drawings will fill most of the survey needs in such a case.)

3. Specifications of the necessary equipment and installations to do the job.

4. A cost estimate.

Items 2, 3 and 4 will be incorporated in a report as to a client. Item 1 may be made the subject of a written examination and carry credit for an introductory—one semester—course in that subject.

Factors Toward Success

The following factors would be of great help towards the success of such a course.

The engineering library must be adequately equipped with the most helpful books in all the fields that are likely to be encountered, including the best basic theory books, the standard handbooks and cost books, catalogs, etc. This does not necessarily imply a very large library, but it does imply a resourceful, competent and efficient library service with an up-to-date basic collection, and geared to promptly buy, borrow or otherwise secure what is needed and lacking at the moment.

2. Alumni can be very helpful in the shaping up of such a program. (a) They can suggest projects, for which perhaps they can also offer some facilities; (b) make helpful hints on how to go about these projects; (c) and serve as critics on the final reports.

It would be desirable that the school keep up a list of a dozen or more projects for the students to select from. Such a list would mean that (a) the literature of the field of the project is reasonably well covered in the engineering library, (b) catalogs and other supply information are available, (c) and a real application is available for the project. A project suggested by a student, if reasonable, may be given preference.

3. Non-engineering drudgery, such as typing, should be reduced to a minimum, resorting to paid help if necessary. All padding—characteristic of student theses—should be eliminated from these reports.

4. Both competition and cooperation may be fostered among the students. They may cooperate on a survey to save time. Also civil engineers may tackle one aspect of a project (say the bridge part of a lift-bridge), and the electricals and mechanicals another (the lift equipment). After a cooperative survey, the students may compete on the practical solution of the problem, both cost and performance being considered.

5. Invention is a very appropriate project in such a course, but it must be an elective since it requires special talent. If elected, a working model must of course be produced.

A project will have a major subject of study but may also have one or more secondary subjects for collateral study. Invention and development, and some other projects too, could be made an opportunity for learning drafting practice, without appropriating special time for it. Those who do the minimum drafting necessary for their project, will have learned enough drafting for most purposes, while those who enjoy it and do a great deal of it, may be given special credit for it.

Graduate Program in Engineering at the U. S. Naval Ordnance Plant in Indianapolis, Indiana*

By W. E. HOWLAND, *Professor of Sanitary Engineering*

and

G. A. HAWKINS, *Dean of Engineering, Purdue University*

Need for Graduate Instruction in Industrial Centers of Indiana

Purdue University offers formal academic engineering instruction to college graduates not only on the main campus at Lafayette in west central Indiana but also at three large urban centers: at Hammond in the northwest, at Fort Wayne in the northeast and at Indianapolis in the central part of the state. We have long had a large engineering undergraduate program going on at these centers but until last year the graduate programs consisted mainly of isolated courses or pairs of courses in specialized subjects of industrial importance and of refresher courses given in preparation for the engineer's training examinations. These courses rarely led to a graduate degree. There have been a number of requests for a formal off-campus master's level program of one sort or another. In Fort Wayne the demand centers on electrical engineering, especially electronics, but in other areas, although the total number of requests is significant, the numbers in any one conventional division of mechanical, electrical, civil, chemical engineering, etc., have seemed, hitherto, to be too small to warrant the setting up of a complete program. This appeared to be true at the U. S. Naval Ordnance Plant at Indianapolis which in November, 1950 requested that the University offer a curriculum of graduate instruction for their employees. Partly for this reason the type of program chosen for this, our first off-campus master's level program, was an integrated one —a definite attempt to bring together a coordinated group of courses at the graduate level that would be of value to mechanical *and* electrical and even to civil and perhaps also to chemical engineers.

Objectives of the Program

A more important reason for the integrated program was, in the eyes of the committee, charged with the responsibility for formulating the details of the courses of the program, that coordination of engineering knowledge and methods at the master's level is, in itself, worthwhile. At the very start of our deliberations we wrote as follows:

> It is recognized that some specialization is absolutely necessary, no one mind being large enough to contain all the facts to say nothing of understanding their relations in even one field of modern knowledge, like engineering. There are those who ascribe the great progress of technology to this very specialization. But this tendency has reached, some feel, a point of diminishing returns and the need has now arisen, especially in engineering, for more men whose range of understanding covers at least the main methods of thinking that have been developed in the so-called basic engineering sciences. We need specialists it is true but we need specialists who know enough about their associates' specialties so that they can put their questions to them and understand the answers and, in general, effectively co-

*Presented at the Annual Meeting of the American Society for Engineering Education, June, 1953, Gainesville, Florida.

operate with them as teams to solve practical problems which are almost certain to require the knowledge of many specialists. To meet this need, to broaden the scientific understanding of the specialists, this particular experimental curriculum has been devised.

And we believe that a specialist so trained will not only be better able to cooperate with his associates but because he has a better understanding of the fundamental laws, principles, and tools of engineering from learning of their applications in related fields he will be able to do a better job in his own field. What he misses in detailed information he will gain in intellectual range and power.†

Thus the key word to describe the purpose of the new curriculum is "integration"—the making of a whole out of an infinitude of infinitesimal parts. The parts are the innumerable facts that the student accumulates in the course of his reading and schooling, and working; the whole is the supporting of those facts on the skeleton framework of the fundamental laws and principles of engineering science with the vital connective tissue of mathematics and then their control through a sort of central nervous system that we call "mode of analysis."

In the courses that we have planned we have emphasized the similarities of some of the basic phenomena and methods of the engineering sciences. We hope to teach how a method of computation of currents and voltage drops in an electric circuit may be used in the evaluation of an hydraulic or thermodynamic or even in an acoustic circuit and why the solution of a differential equation that happens to apply to a problem in torsional stress distribution also explains the slope of the deformed membrane over an opening identical in shape to the cross section of the shaft, thus forming the basis of an experimental technique for stress study, —the so-called membrane analogy. When our students have learned in heat transfer how to determine the way the temperature changes in a flat plate as it loses heat at one central point they may be able immediately to apply this method of solution to the problem of falling water levels in the aquifer around a well being pumped. In other words, we made a deliberate effort to extend the use of our methods of analysis to many fields. We have tried to sharpen up these methods as tools that would cut into many kinds of material.

† Graduate Engineering Program at U. S. Naval Ordnance Plant, Indianapolis, Indiana, Report No. 1, History and General Considerations, by W. E. Howland and G. A. Hawkins, pp. 4–5.

Adopted Courses of the Curriculum

Our present program for accomplishing this objective consists of four courses of mathematics called "Advanced Engineering Mathematics I & II," covering Reddick and Miller and part of Churchill's "Operational Methods," then Applied Complex Variables and Vector Analysis. Next comes a course in Selection of Materials for Engineering Structures, followed by Analysis of Deformable and Non-Deformable Systems, the Thermodynamic Mode of Analysis, Thermal Circuits, Fluid Circuits, Theory of Fields and Circuits (a 9 hour course) and Human Phases of an Engineering System. The final integrating course is called Analysis and Synthesis of Engineering Systems, in which the real practical engineering problem that involves many engineering sciences will be attacked.

How the Plan Was Evolved

A word about the way in which the plan was evolved: Dr. K. L. Nielsen, Chairman of the Professional Development Committee of the U. S. Naval Ordnance Plant at Indianapolis, initiated the inquiry to the University and, with his colleagues, met occasionally with the University committee while they were formulating the curriculum. This committee appointed by Dean A. A. Potter and headed by Dr. G. A. Hawkins met once each week for one academic year to decide upon the basic policies and then to work out the details of the plan. Dean L. M. K. Boelter served as consultant to the committee.

The individual members of the committee were asked to devote their especial attention to the courses which presented the material in which they were especially trained: to study the subject matter available in the textbooks, to consider appropriate methods of presentation, to illustrate these methods before the committee, to present the modes of analysis, to outline the course material, both in preliminary and in completed form, and as far as time permitted, to prepare supplementary material needed for instruction, especially that which was not already available in the textbooks.

The first thing our committee did was to formulate what we called the modes of analysis that we employ in our several fields of engineering sciences to determine, if possible, a general pattern that is common to them all. In this venture we were successful. The pattern is common to all of the fields of engineering and to all of the kinds of problems that engineers as engineers are expected to solve. And—we personally believe—that it applies to all fields in which problems can be solved.

However, we confined our attention to the professional phases of engineering and deliberately and intentionally omitted fringe activities. (In medicine the care and cure of the human body is generally recognized as the core of the practice of medicine rather than financing medical care, hospital management, bill collecting, or the distribution and sale of medical products; ability to cure defines the physician. So in engineering, the non-specific professional activities, however important, should not, we thought, be allowed to obscure the essential problem-solving nature of the practice of this profession.)

General Discussion of the Courses Studied

Perhaps the most distinctive features of our curriculum is the emphasis it places upon the general mode of analysis. This is a topic that will be discussed at another session of this conference in a paper of that title by L. M. K. Boelter and G. A. Hawkins; consequently, it may be sufficient to state here merely that this most effective procedure for using the intellect is applicable, we believe—in a slightly more generalized form to all types of engineering problems. Perhaps we should say that we believe the general mode of analysis is an essential part of what has often been called the scientific method and that the scientific method so strengthened is widely applicable to engineering problems. In particular, it provides an effective procedure for solving the three types of problems that engineers most frequently encounter: (1) the prediction of performance of structures, machines, processes, circuits or organizations, (2) their design or planning and (3) the explanation of observed phenomena as encountered in their operation.‡

The method slightly generalized thus helps to find answers to the questions: "What will happen?", "How to make it happen?", and "Why did it happen?" As applied to the great area of human values it may also help the engineer to decide "What should happen?" If so, it would help powerfully to integrate the entire realm of organized knowledge for effective use by the engineer. This glorious but distant goal of engineering education our committee has not lost sight of and our inclusion of a course called "Human Phases of an Engineering System" bears evidence of our broader aims.

Results of the Plan of Study

It is undoubtedly too early to attempt an appraisal of the curriculum set forth in this paper. The mathematics courses have been given to one group of students but, beyond these, only two other courses

‡ Note: A detailed presentation of the more generalized method for dealing with all three types of problems and the consideration of the entire engineering curriculum as a "Preparation in Method for Explanation, Prediction and Design" is contained in Report No. 2, Development of the Graduate Engineering Program at the U. S. Naval Ordnance Plant, Indianapolis, Indiana, by W. E. Howland and G. A. Hawkins.

have been taught: Selection of Materials for Engineering Structures, and Analysis of Non-Deformable and Deformable Bodies. From teaching the latter course the indications are that the sights of the curriculum makers were set a little too high (nearer the doctor's than the master's level)—that the mathematical ability and interest in the abstract phases of engineering analysis of the older engineering graduates at work in industry are no higher and are perhaps somewhat lower than of the younger graduate students we encounter on the campus. Consequently, it is probable that modification will be made in the original course outlines in the direction of simplification and rearrangement of the material of the mathematical courses (1) to give greater emphasis to those topics that are essential to the methods employed for the solution of problems in other courses, and (2) to postpone some of the instruction in mathematics to a later time in the program, thus effecting a closer integration of subject matter, in line with the stated objectives of the curriculum. It is possible that the superior understanding of the physical phenomena by these more mature students will permit a greater elaboration and enrichment of the instruction in the nature of the phenomena than had originally been thought possible. The program will still be definitely of a master's level or a little higher.

In any case it is almost certain that modifications should and will be made. Good curricula like good laws cannot be merely enacted—they must grow!

Conclusion

This curriculum follows what appears to be a modern trend of "integration" which has manifested itself in the whole field of education as well as in engineering education. But in a real sense we are pioneering. We are proposing to abandon conventional subject matter boundaries, to reshuffle the deck of engineering facts in a new way and to play the game according to somewhat different rules. Instead of constructing a master's degree program so as to proceed further into a particular specialty from the base of previous training, we are proposing to broaden and to strengthen the foundation itself. Thus, we hope to help our students erect a deeper and stronger structure of knowledge on which eventually an even higher and certainly a stronger one will be erected than would otherwise be possible.

ANNUAL MEETING

June 14-18, 1954

University of Illinois **Urbana, Illinois**

Physics for the Civil Engineer*

By N. W. DOUGHERTY

Dean of Engineering, The University of Tennessee

Introductory

There has been little change in the beginning course in physics during the last forty years. This may be good or it may be bad, depending upon the possible additions of new subject matter in the field of physics and changes in other, and parallel, courses in engineering. Statics, dynamics, heat, light, sound and the elements of electricity were the major topics studied during the first decade of the century, and these same topics are being taught in about the same way at the present time. Laboratory equipment is usually better, textbooks contain more illustrations, but, because of the number of students and the elementary nature of the subject, the teachers of engineers are not always the most experienced and best prepared staff members of the department.

If the philosophy of physics remains the same, and if engineers need to study the same subject matter as they did forty years ago, there is good reason for little change. Most of the subject matter in the beginning course was developed long before 1900. Sound, heat, light and electricity have passed beyond the elementary stage and have already reached maturity enough for the physicists to think of them as advanced physics. Teachers in engineering have developed volumes on mechanics, fluid mechanics, thermodynamics and elements of electricity; these works should have completely changed the picture in physics, but little change has come about.

Parallel Growth of Civil Engineering

Civil engineering programs, during the last one hundred years, have depended upon physics to give instruction in statics, dynamics, heat, light, sound and elements of electricity. This was especially true during the second fifty years of the last century. Indeed, there was a comradeship of the civil engineer and the physicist as they battled for a place in the college curriculum; they jointly pushed out languages, literature, philosophy, religion and a resistance to science and technology, and put a certain amount of utility into college curricula. Physics, chemistry, the biological sciences and technology changed the attitude of educators toward college education.

During the early development of civil engineering, and all engineering, for that matter, the courses were descriptive. They described methods of doing things, how to build machines, structures, railroads and factories and spent little time on the theory behind the building. Physics furnished the theory they needed. Mahan's "Civil Engineering," first published in 1846, was continued as a text for fifty years. Even in his chapters on structures and bridges, he does not give a single calculation of stresses in the members. He describes tests of models, and gives methods of selecting compression and tension members, but he does not introduce the elements of mechanics. If the student studying civil engineering during this period, needed a knowledge of mechanics he had to depend upon his physics for that knowledge.

The "Municipal and Sanitary Engineers' Handbook," by Bulnois, the third edition of which was published in 1898,

*Presented at the Annual Meeting of ASEE, Physics Division, University of Florida, June, 1953.

gives descriptions of the construction of roads, streets, sewers and buildings, but does not use any mechanics for sizes or thicknesses or any hydraulics for sizes of pipes or sewers. Again, if the student needed any mechanics of solids or fluids, he had to depend upon his course in physics.

Loads were increased, new materials were introduced; sizes must be computed rather than determined by rule of thumb. The civil engineer needed more knowledge of mechanics and fluid flow than he was getting in the physics courses; consequently, he wrote his own books in these fields. New materials, new methods of construction and economy measures caused him to develop the mechanics of elasticity in order that he might build rigid frames, continuous bridges, skyscrapers, concrete structures and pavements. Elementary physics no longer served his needs; yet he continued it in his educational program with the knowledge that he would repeat practically all the subject matter in statics, dynamics, and fluid flow, and that he would ask the mechanicals to teach heat in a course in thermodynamics, and he would ask the electricals to teach the elements of electricity. He needed more theory in all these areas than he was getting in elementary physics.

By this time, other engineering departments were looking at physics with a critical eye. Either they were expecting too much, and not allowing enough time, or the physics department was out of step with the needs of engineering.

During the last twelve years, we have made two major studies of the courses in physics required of all engineering students. Each time the committee has been made up of representatives of the engineering departments and members of the physics staff. They come back with a majority and a minority report. Engineering faculty members suggest fewer topics and more time on each topic; the physics teachers ask for more time to teach all the topics well. It seems obvious that a major operation is needed to solve the problem.

Major Criticisms

Out of the two studies, and from conversations with engineering faculty members it appears that there are at least two major criticisms:

1. There is an effort to cover too many topics—too much subject matter, and
2. The approach is not in the attitude and spirit of the engineer

To say that there is an effort to cover too much subject matter is but to state a fact on which all will agree, but the same may be said of all the engineering courses. One of the greatest faults of engineering programs of today is the effort to cover too much subject matter. Teachers are assigning so many pages that they have forgotten that the objective of college is learning and not intellectual drudgery. During the last three hundred years, physicists have developed so much interesting and useful material that they can spend four years on a major as preparation for graduate work. Obviously, their review of the field for engineers cannot be very deep. Let us forget about trying to cover the field and try to develop an ability in the student to work under his own steam. If he ever discovers how to learn, he will be able to acquire knowledge, as needed, during a career of useful work. Few of those who are advancing knowledge today learned all they needed to know while they were in college.

That the physicist's approach is not that of the engineer does not worry me too much, provided students get the approach of the physicist. If the courses must be likened to the circus, where the spectator views the topics and may not recognize them the next time he sees them, there is, as Governor Dewey put it, "time for a change." Engineering faculty members do not help the physics department by telling their students they have had this in physics, but will have to learn it over again. There may be questions of units and lists of names; there may be a theoretical and a practical approach, but the real problem has not been touched.

Suggested Solution

We are all fighting for time. Each decade, yes, each year, brings new ideas to develop and new techniques to master. We do not have enough time to teach everything. We add a new topic, but do not take anything out; we must find an answer to an impossible situation. The answer is not five or six year programs, but more efficient use of the time in four years.

Why duplicate the teaching of statics, dynamics, fluid mechanics, heat and electricity? The physics course will not give enough instruction in these topics, and the engineers will do it over again. Let the engineers take the topics over and teach them as they please. Give the physics department at least as much time as it now has and ask it to teach something the faculty members know and wish to teach. Their research is not in the fields just named; they are out on the borderline of knowledge, looking for new things rather than poring over things their grandfathers knew. New applications of the laws of physics are constantly in the making; engineers have this task; consequently, they are doing research in methods, in new applications and new statements of old laws. Let them teach the things they know.

Engineers need to know more about light, sound and nucleonics. Immediately we hear that nucleonics cannot be taught as a beginning course. This may be true, but who is suggesting it as a beginning course? If the time devoted to physics were delayed a semester, the engineering student will have more mathematics than for the present course, and he will have had more statics, dynamics and fluid mechanics than the physics major, who does take courses in nucleonics. Indeed, it is possible to arrange the sequences in such a way that engineers will be better prepared for advanced physics than they are now. They are lost in a wilderness of many things.

This country has been fortunate in its pioneers. Wherever there were barriers to expansion or progress there have been pioneers who surmounted the barriers and opened up new lands and new vistas. No one has felt that these pioneers are the only persons who know how to occupy the land after it has been opened up. Another kind of pioneer has followed the trails, has consolidated the gains, built up the cities, the industries and the universities.

The pioneers in mechanics, heat, light and electricity were usually physicists, though recent developments in these fields have been by engineers and in engineering laboratories. Traditionally, we have asked the people in physics to give the beginning instruction, largely because their ancestry developed the materials. Now that engineers have also entered the fields of mechanics, hydraulics, heat and electricity, and are making contributions to these fields, there is no good reason why they should not occupy the land.

Conclusions

We have pointed to the parallel growth of civil engineering teaching and physics teaching; we have mentioned the early dependence of civil engineers on physics for the scientific approach. The interests of teachers of physics have turned from mechanics and hydraulics to modern physics and nucleonics; engineers have taken up the baton of mechanics and fluid mechanics and are adding to methods and techniques. Let us drop mechanics, fluid flow, heat and electricity from the physics program and place the responsibility for these subjects on the engineers.

With the time now devoted to elementary physics, the physics department could give better courses in light and sound and add an elementary course in the field of their greatest interest, nucleonics. Instead of trying to occupy the land they discovered many years ago, they will turn it over to the developers and builders, and search out new lands which succeeding generations will occupy and develop. Civil engineers will be benefitted by the change and the physics instructor will be relieved of a task which is very difficult, if not impossible, to perform.

Books on Mathematics for Engineers and Physicists. How Can They Be Improved?

By A. F. PUCHSTEIN

Jeffrey Manufacturing Company, Columbus, Ohio

Those who use books of this type must be impressed by the differences between them and their inadequacies. The labor required to use them is out of proportion to the difficulty of the material. This is due more to the way in which it is presented than to deficiencies in mental equipment. A preferable arrangement undoubtedly exists and should be explored. But here attention will be directed more to the method of treatment than to topics that should be included. The latter would be selected from those available. These could be arranged in some orderly sequence by subjects, order of difficulty, or settled by a conference.

These books are generally written in the language and style of the mathematician. They usually assume that the user can read the text at sight, that he knows the exact meaning of all terms, symbols, and expressions; and that he can apply them without further direction. Rarely do they give tables of symbols or definitions. Sometimes no index is given. Often cross-references are few. There is little attempt at standardization. Frequently the text is closely printed in long paragraphs with makeup and topography such that the material must be read to identify it. The procedure in going from step to the next is not always given. Little use is made of the artist, draftsman, illustrator, or language expert.

Some books give the mathematics only, with and without examples. Some add examples from applied science or engineering. Some are prevailingly treatises on engineering or physics with the mathematics woven in. Some keep the mathematics and engineering separate while others do not. Frequently, different practices are found in the same book.

It seems best to keep mathematics and applications clean cut and separate., that is, to follow up the mathematics with examples of the applications placed in separate paragraphs or even in other sections of the book, and not to intermingle them in the same lines. Of course, since many of these processes are the result of trying to solve some physical problem, there exist cases where it is better to state the problem and then to outline the mathematics used in solving it. It would not hurt even to outline some problems for whose solution no mathematics are available.

Poorly Illustrated

Most books are not well illustrated nor are they always written so that the ideas, principles, operations and procedures stand out. The understanding and application of many theorems and formulas could be made more clear by numerical, analytical or physical examples. To proceed from the particular to the general is often easier to understand than is the reverse. Much greater use could be made of line and perspective drawings, sections, phantom views, half-tones, photographs, colors and pictures of models. Simple notations are to be preferred.

Too many proofs in the working parts of the text tend to obscure the substance and so are best given at the end of a chapter, book, separate volume, or left to

a reference. Also, instead of formal abstract proofs, it is often better to use the more easily understood numerical proofs. It is a question whether in books of this character proofs need be given at all. At work, it is essential to know only that the material is correct, on what assumptions it is based, what operations are permissible, conditions under which they fail, restrictions that must be observed, correct interpretations, what applications it is good for, and how to use it. Anything else usually is wasteful and unnecessary and can be looked up in more formal works.

In spite of brilliant exceptions, the applied mathematician is less often in position to do his own mathematical research. The conditions under which he works ordinarily are not favorable for leisurely reading, contemplation or this kind of research. He is hampered by noise, pressure, lack of privacy, rustiness, inadequate library (this often confuses rather than helps), preoccupation with physical details, and other work. Accordingly, his needs are best served if the material is set up so that the salient features can be overseen quickly, precisely, and completely, with as few words as possible. The emphasis, therefore, should be more on manipulation, procedure, and methods of solution than on derivations, proofs, or philosophy involved, although these have their place if presented briefly.

In the case of differential equations, expressions from vector analysis, etc., it is important to state what each term (or even the whole expression) means physically in different fields of application. It would be a great help to have a tabulation of the different ordinary and partial derivatives, with that they mean in different sciences. Likewise, it would be useful to tabulate the more important differential equations (ordinary and partial) used in science and engineering, with interpretations and an outline of the methods of solution available, together with some examples of the solutions obtained. Sometimes it is instructive to indicate the mathematical solutions that result when boundary conditions are ignored.

Most students have difficulty with the meaning and application of certain concepts. It would help such people greatly to give numerical and other examples from mathematics, science, physics and engineering, or their subdivisions, as mechanics, hydraulics, fluid flow, heat, elasticity, sound, electricity and magnetism, etc.

To obtain a result when exact solutions are unwieldy or cannot be obtained, a section should be devoted to the best approximation methods available for obtaining solutions graphically or numerically. This would include algebraic and transcendental equations, derivatives, definite and indefinite integrals, ordinary and partial differential equations, calculus of variations (as the Rayleigh or Ritz Method), integral equations, matrices, etc.

In these days, it would be helpful to list also some of the special slide rules, machine methods, and large-scale computors, with some indication of their capabilities and limitations for computation and industrial applications.

Summary

To prepare a work of the kind envisaged here will not be easy. The mark to shoot at is not too definite. The need is different for differt people and changes with time. To get it out at a popular price will be something of a problem. But a suitable 1, 2 or 3 volume work would save many times its cost. Anyway, it is clear that some important bets have been overlooked and that such works can be made more useful for instruction, review, or reference if the problem is studied by a competent group and the work tailored to fit more nearly the job to be done. Such works are not for the novice, but still they must be addressed to those who are something less than accomplished mathematicians. The possibilities of using more common everyday

language have scarcely been explored. Of course, it is not always possible or desirable to get away completely from the conventional mathematical terms, language or treatment. It would be desirable to give some examples to show how certain topics were presented and how they should be presented. But this is impractical in a paper of this length. An example of the treatment proposed here might be the section on Mathematics, pages 2–02 to 2–48 of Eshbach's "Handbook of Engineering Fundamentals." See particularly pages 2–13 to 2–23. It is imperative to make such texts less a puzzle, more standardized, and a better vehicle for transmitting the information. It is hoped that future writers and publishers will recognize the problem and make a group attack upon it.

ANNUAL MEETING

June 14-18, 1954

University of Illinois **Urbana, Illinois**

TIMELY TIPS

The Value of Exaust Gas Analysis

By JAMES L. EDWARDS

Associate Professor, Mechanical Engineering, Clemson Agricultural College

In conducting experiments on exhaust gas analysis, the writer has noticed that many students concentrate so on mastering the physical manipulation of the Orsat that they either fail to grasp, or minimize, the real significance of gas analysis. Clouded in their thinking, or even pushed out of the picture, is an appreciation of the fact that exhaust gases can, and do, tell a story of the type combustion from which they resulted. Sometimes completely overlooked is the knowledge of why the CO_2 content alone in an exhaust gas resulting from the combustion of fuel and oxygen is indicative of the conditions surrounding this chemical reaction. To emphasize the need and the value of knowing the composition of an exhaust gas, the writer has found the following approach helpful.

First, point out to the students that a deficient supply of air results in an insufficient number of oxygen molecules for the complete liberation of the chemical energy stored within the molecules of carbon, hydrogen, and possibly sulfur, in the fuel. An incomplete liberation of energy means an economic loss and thus is wasteful in terms of dollars and cents because something has been paid for which is not being fully utilized. Second, call attention to the fact that an excess supply of air results in a greater than necessary quantity of oxygen molecules. This surplus of oxygen causes the complete liberation of the chemical energy in the fuel (assuming proper mixing) but represents an excessive heat loss out of the stack as the excess air has to be heated through the same temperature range as do the normal products of the combustion. Also, this extra supply of air furnished represents a larger volume to be handled by the fans and ductwork which in turn entails larger installed capacity and greater expense. Obviously then, combustion with the theoretical amount of air is desired (provided mixing is complete) as it represents both the complete liberation of chemical energy and a low stack gas loss.

With this fact firmly established the writer then has each student write the equations for the combustion of a single hydrocarbon such as propane, C_3H_8, for example, with theoretical air and with 80% and 120% theoretical air. The following equations result:

(a) Stoichiometric : $C_3H_8 + 5\,O_2 + 18.9\,N_2 \rightarrow 3\,CO_2 + 4\,H_2O + 18.9\,N_2$

(b) 80% : $C_3H_8 + 4\,O_2 + 15.12\,N_2 \rightarrow CO_2 + 2\,CO_2 + 4\,H_2O + 15.12\,N_2$

(c) 120% : $C_3H_8 + 6\,O_2 + 22.7\,N_2 \rightarrow 3\,CO_2 + O_2 + 4\,H_2O + 22.7\,N_2$

A study of the exhaust products reveals that for theoretical combustion there results 3 mols of CO_2. Since there are 25.9 mols of products formed, there is then a percentage by volume of CO_2 in the products equal to 3/25.9 or 11.6%. Similar analysis for the remaining two equations shows that for combustion with 80% theoretical air, the per cent CO_2 in the

exhaust products is 4.52% whereas with 120% theoretical air it is 9.78%. These figures establish the fact that the highest per cent CO_2 is obtained when the correct quantity of air is supplied for the fuel.

This approach to the problem usually convinces a student of the value of exhaust gas analysis in general, and of the importance of determining the per cent CO_2 in the products in particular.

Reprints Available . . .

Reprints of the "Code of Ethics of Interviewing Procedures can be obtained from the Secretary's Office for 15¢ each or $8.00 per hundred.

Also available are copies of the "Manual of Graduate Study." The price is 50¢ per copy.

The "Report of the Committee on the Improvement of Teaching" is available for 15¢ each or $8.00 per hundred.

All orders should be accompanied by a check or money order.

Minutes of Executive Board, New York City, N. Y., January 18, 1954

A meeting of the Executive Board of the American Society for Engineering Education was held on Monday, January 18, 1954, at the Statler Hotel, New York City, New York. Those present were: L. E. Grinter, *President;* W. L. Everitt, B. R. Teare, Jr., E. A. Walker, W. C. White, *Vice Presidents;* G. W. Farnham, *Treasurer;* A. B. Bronwell, *Secretary.*

Report of Secretary

The Secretary reported as follows:

1. The UPADI Convention for 1954 will be held in Sao Paulo, Brazil, August 2–13, 1954. The ASEE has been asked to appoint one representative. Action was deferred pending more information as to who would attend the Conference.

2. The EJC has achieved substantial agreement with the National Science Foundation on the method of handling the National Scientific Register of Engineers. Instead of attempting to keep an up-to-date list of all outstanding engineers, it has been decided that there shall be a finder list, consisting of approximately 5,000 names of people engineers. This finder list can then be used to locate needed personnel in any specialized branch of engineering on short order if an emergency should arise.

3. Who's Who in Engineering will be available in February, 1954.

4. At the Engineering Manpower Commission it was brought out that UMT is shelved for this Session of Congress at the request of the President, pending reorganization of the Reserves. The Reserve reorganization plan calls for setting up an immediately available reserve corps with a high degree of training which could be called on short notice in the event of a national emergency. This will be backed up with secondary reserves which would be selectively called in such a manner as not to cripple industry.

5. It has been pointed out that draftees in the Armed Forces can be recalled back to civilian service three months ahead of their normal termination date if they have a contract for services. This feature might be helpful to engineering colleges which are hiring personnel for either research or faculty positions.

Report of Treasurer

1. The financial report for the second quarter was presented and accepted. It was estimated that the income and expenses projected ahead to the end of the year would come close to the budgeted figures, except for Institutional Dues which are approximately $1300 over the budgeted amount.

2. The Board voted to transfer the Life Membership fund to the general fund of the Society and to discontinue the practice of transferring $25 annually from the general fund of the Society to Life Membership.

3. The Secretary stated that the work of the Headquarters office staff is becoming very heavy and will continue to grow with the planning of the Annual Meeting superimposed upon the normal business. The Executive Board voted an additional $500 for office secretarial help.

4. The Secretary reported that he had been asked to take on the Chairmanship of the EJC Committee on Secretaries. This Committee shapes up a number of the programs of Engineers Joint Council and therefore is a rather influencial Committee. Since this is a non-recurrent item, the Executive Board voted to authorize $500 additional travel to be charged to the Special Projects Reserve.

5. The Executive Board voted to charge the $250 travel expense of the Sub-Committee on Physics against a special projects reserve.

Request of Trade Associations for Article

A request of the American Trade Association Executives for an article dealing with

how Trade Associations can assist engineering education was referred to the ECRC.

Educational Television

The program of the American Council on Education for the expansion of educational television was reviewed. It was suggested that the ASEE appoint a representative to the American Council's Committee. Vice President W. C. White will write to Dean Sweigert, Chairman of the Educational Methods Division for his recommendations.

International Relations (ECAC)

Vice President Everitt stated that the Committee on International Relations is studying the possibility of getting industrial acceptance of the principle of hiring foreign students so that these students can gain experience in American Industry. If the National Association of Manufacturers could be persuaded to recommend this to its constituents, this might help to break down the barriers of industry opposition to the hiring of foreign students. The Secretary reviewed previous correspondence relating to a proposal by Dr. Newby of the Imperial College of London and Professor Arthur Tichenor of Purdue University to bring students from England to the United States for industrial experience.

Annual Meeting

The program for the General Sessions and principal events at the Annual Meeting was outlined as follows:

On Monday afternoon there will be a Session entitled Reports of ASEE Committees. This will include reports of the Humanistic-Social Division, Committee on Ethics, Engineering Manpower Committee, Salary Survey of ECAC (if completed by that time) and the Summer Institute Program. The General Session on Tuesday morning will be scheduled for 9:00 A.M. and will include the election of officers and addresses by President Morey (University of Illinois) and President Grinter. There will then be a 1½ hour panel discussion of the final report of the Committee on Evaluation of Engineering Education The ECRC General Session on Wednesday morning will have 3 or 4 speakers who have made distinctive creative contributions, discussing the problems of creative thought. The Thursday morning General Session will be a joint Session of the ECAC, Educational Methods Division, Committee on Recognition and Incentives for Good Teaching, and YET dealing with the subject of recognition and incentives for good teaching.

General Council members and wives will be guests of President Morey at a dinner meeting on Monday evening. The Council will also hold a breakfast meeting on Friday morning.

The ECRC and ECAC will have a joint dinner meeting on Tuesday evening to commemorate the founding of the first Engineering Experiment Stations at the University of Illinois and Iowa State College.

There will be a President's tea and reception at 8:30 P.M. Tuesday. The General Entertainment will consist of a play on Wednesday evening. The Annual Banquet will be on Thursday evening. President Keith Glennan of Case Institute has consented to speak.

There will be a breakfast meeting of the Chairmen of Sections and Branches Wednesday morning and a breakfast meeting of Chairmen of Divisions and Committees on Thursday morning. It was suggested that these be cafeteria breakfasts in order to speed up service.

The Executive Board voted to accept the budget proposed by the University of Illinois and allow a registration fee of $4.00 per member.

Humanistic-Social Project

The grant of $30,000 to ASEE by the Carnegie Corporation was announced. The Executive Board recommended that an agreement with North Carolina State College be negotiated for Professor Gullette's services from January 1, 1954, to September 1, 1954. It was suggested that the project might best be handled by a Steering Committee of five to seven people and an Advisory Board which would meet less frequently, consisting of fifteen to twenty outstanding authorities. Vice President White will arrange for a meeting with Dr. Gullette and Dr. Olmsted.

Evaluation of Engineering Education

President Grinter stated that the General Electric Company had offered to contribute $10,000 to the Society for the Evaluation of Engineering Education project. The

next meeting of the Evaluation Committee will be in Atlanta, Georgia on February 18–20. Sub-Committees will be appointed at that time to prepare a draft of the final report.

By-Law Amendment

The Amendment to By-Law IV relating to dues of individual members was unanimously approved by the Executive Board. The Amendment will be submitted to the General Council for vote about February 1 and to the Society membership for vote in April. A Teller's Committee consisting of Dean Owens, Dean Treise, and Professor Obert was recommended.

Printing Costs

Mr. Farnham presented estimates on costs of printing the *Journal of Engineering Education* using the off-set process. These showed no savings on printing of the monthly issues, but a possible saving of approximately $1900 on the *Yearbook* after the first year. Mr. Farnham will clear up several matters relating to these estimates.

Summer Institute Program

The Secretary reported that the National Science Foundation had approved the proposals for the two Summer Institute programs. (Information regarding these conferences is given elsewhere in this issue of the JOURNAL.)

The Executive Board discussed future programs for the Summer Institute Conference. Suggestions included conferences on combustion, fluid mechanics, thermodynamics, and graduate study.

Cooperative Research Foundation

A request by the Cooperative Research Foundation for funds to prepare a directory of Engineers and Scientists for use of foreign visitors was rejected.

Social Security for Secretarial Staff

The Secretary pointed out that the Society does no provide Hospitalization nor Social Security for the secretarial staff. This affects only one of the office secretaries, since the other two have such benefits in connection with their husbands' employment. The Executive Board suggested that the Secretary inquire about possible ways of getting Social Security benefits for the other Secretary.

Application for Institutional Membership

The Executive Board voted to grant active institutional membership to the University of Dayton and Associate Institutional membership to International Resistance Company and the America Machine and Foundry Company.

Exchange of Publications with UPADI

A request of EJC that the Engineering Societies consider exchange of technical publications with Latin American Countries was discussed. It was recommended that the Society review its present list of free distribution of the JOURNAL and revise this to include institutions which will make the JOURNAL available to the largest number of people in foreign countries.

Next Executive Board Meeting

The Executive Board voted to hold its next meeting at Rolla, Missouri on April 9. Transportation will leave St. Louis at 8:00 A.M. in order that the meeting start at 9:30 A.M. This meeting will be held in conjunction with the meeting of the Missouri-Arkansas Section.

Respectfully submitted,

ARTHUR BRONWELL,
Secretary

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

PROFESSOR OF PHYSICAL METALLURGY—experienced in research direction and graduate instruction. Ph.D. or equivalent, to head educational option in physical metallurgy and direct thesis and contract research. Excellent opportunity for expansion in an outstanding center in the Middle Atlantic region. MR–1.

INSTRUCTOR IN ELECTRICAL ENGINEERING for September, 1954, to teach undergraduate theory and laboratory. Opportunity from graduate work in electronics or control. Apply to Chairman, Division of Engineering, University of Rochester, Rochester 3, New York.

INSTRUCTOR IN CHEMISTRY (ENGINEERING Field) to take charge and build up department in an Eastern Technical School; preferably a man with advanced degree and some industrial experience, who desires to teach and has leadership ability. Opportunity for research. MR–2.

INSTRUCTOR IN ELECTRICAL ENGINEERING. Man who is familiar with electric power engineering and also who has some knowledge of electronics, preferably one with some industrial experience. For the right man, permanent position and advancement. MR–3.

(1) ENGINEERING DRAWING Teacher-Drawing, descrip. geom., machine design. (2) Production Processes Teacher-Machining, welding, casting, metallurgy. (3) Construction Engineering Teacher-Surveying, str. of metls., constr. pract. M.S. degree plus industrial experience. Excellent opportunities in young dept. for instructor or assistant professor. New bldg. and equipt. Good salary scale. San Jose State College, San Jose, Calif.

PENNSYLVANIA STATE UNIVERSITY. Instructors for off-campus centers in electrical, structural, drafting and design subjects. Faculty participates in hospitalization, retirement, insurance, and tenure plans. Apply to Terminal Study Dept., General Extension Bldg., State College, Pa.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	University of Pittsburgh	April 30–May 1, 1954	W. I. Short, University of Pittsburgh
Illinois-Indiana	Illinois Institute of Technology	May 15, 1954	R. G. Owens, Illinois Institute of Technology
*Kansas-Nebraska	University of Nebraska	Fall, 1954	M. H. Barnard, University of Nebraska
Michigan	University of Michigan	May 8, 1954	F. L. Schwartz University of Michigan
Middle Atlantic	Lafayette College	May 8, 1954	H. M. Jenkins, Swarthmore College
Missouri-Arkansas	Missouri School of Mines	April 10, 1954	V. J. Blum, St. Louis University
National Capital Area	Catholic University	May 8, 1954	C. H. Walther, George Washington University
New England	Massachusets Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	Ohio State University	May 1, 1954	R. S. Paffenbarger, Ohio State University
Pacific Northwest	Oregon State College	April 23–24, 1954	L. Slegel, Oregon State College
Pacific Southwest	California Institute of Technology	Dec. 28–29, 1954	B. M. Green, Stanford University
Rocky Mountain	University of Utah	May 14–15, 1954	A. Diefendorf, University of Utah
Southeast	North Carolina State College	March 25–27, 1954	J. R. Cudworth, University of Alabama
Southwest	University of Texas	April 16–17, 1954	J. J. Heimerich, University of New Mexico
*Upper New York	Cornell University	October, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings

* No Date Set.

New Members

ARCHER, DAVID H., Assistant Professor of Chemical Engineering, Carnegie Institute of Technology, Pittsburgh, Penna. C. C. Monrad, Lawrence N. Canjar.

BAKER, DAVID FLOYD, Instructor in Industrial Engineering, Ohio State University, Columbus, Ohio. Paul Lehoczky, Gordon B. Carson.

BOUTILIER, OSCAR DAVID, Instructor in Civil Engineering, University of Maine, Orono, Maine. W. S. Evans, G. K. Wadlin.

CANNON, MICHAEL R., Professor of Chemical Engineering, Pennsylvania State University, State College, Penna. J. H. Moore, R. E. Armington.

CARNAHAN, F. L., Associate Professor of Chemical Engineering, Pennsylvania State University, State College, Penna. J. H. Moore, R. E. Armington.

CAVALCONTE, CHARLES C., Instructor in Electrical Engineering, Manhattan College, N. Y. C. Brother A. Denis, R. T. Weils, Jr.

CRYDER, DONALD S., Head of Department of Chemical Engineering, Pennsylvania State University, State College, Penna. J. H. Moore, R. E. Armington.

DALY, JOHN FRANCIS, Instructor in Mathematics, St. Louis University, St. Louis, Missouri. V. J. Blum, J. B. Macelwane.

DAVIS, DONALD W., Associate Professor of Electrical Engineering, Ohio Northern University, Ada, Ohio. J. F. Klingenberger, L. H. Archer.

DIETZLER, JOHN PATRICK, Executive Assistant to the Deans, St. Louis, Mo. J. B. Macelwane, V. J. Blum.

DOWLING, ROY E., Instructor in Mechanical Engineering, Lafayette College, Easton, Penna. J. H. Fernandes, H. C. Hamilton.

FERIDUN, KEMAL KLEMAN, Instructor in Mechanical Engineering, Lafayette College, Easton, Penna. A. W. Luce, H. C. Hamilton.

FREEMAN, JACK, Instructor in Industrial Engineering, New York University, N. Y. David B. Porter, John W. Snell.

GENTILE, RALPH G., Assistant Professor of Electrical Engineering, Rice Institute, Houston, Texas. Frank Zozzora, Mike V. McEnany.

GRIFFITH, JOHN EDWARD, Instructor in Engineering Mechanics, Pennsylvania State University, State College, Penna. W. R. Shaffer, J. W. Breneman.

HAM, JAMES MILTON, Associate Professor of Electrical Engineering, University of Toronto, Toronto, Ontario. L. S. Lauchland, G. F. Tracy.

JACKLIN, H. M., Professor and Head of Mechanical Engineering, Ohio Northern University, Ada, Ohio. J. L. Klingenberger, L. H. Archer.

JASTRZEBSKI, ZBIGNIEW DAMAZY, Associate Professor of Chemical Engineering, Lafayette College, Easton, Penna. E. L. McMillen, Hance C. Hamilton.

JENNINGS, NORMAN F., Instructor in Mechanical Engineering, Ohio Northern University, Ada, Ohio. J. F. Klingenberger, Lawrence H. Archer.

LINDLEY, KENNETH EUGENE, Assistant Professor of Electrical Engineering, South Dakota State College, Brookings, South Dakota. W. H. Gamble, J. O. Storry.

LUCAL, HAROLD M., Assistant Professor of Electrical Engineering, University of Connecticut, Storrs, Conn. H. A. Sawyer, Jr., R. J. Kochenburger.

MACCONOCHIE, IAN OLIPHANT, Instructor in Mechanical Engineering, Duke University, Durham, N. C. R. E. Lewis, H. N. Haines.

MORROW, DAVID CLARENCE, Professor of Mathematics, Wayne University, Detroit, Mich. R. H. Schoonover, S. F. Hicks.

PALMER, ROBERT S., Assistant Professor of Agricultural Engineering, University of New Hampshire, Durham, N. H. E. R. Stapley, B. P. Rines.

SCHALLER, GILBERT S., Professor of Mechanical Engineering, University of Washington, Seattle, Wash. B. T. McMinn, E. E. Day.

SCHERBA, MICHAEL B., Assistant Professor of Electrical Engineering, Wayne University, Detroit, Michigan. H. M. Hess, R. W. Grant.

SCHWEBKE, HOWARD JOHN, Instructor in Drawing and Descriptive Geometry, University of Wisconsin, Madison, Wis. R. R. Worsencroft, H. B. Doke.

SEBAN, RALPH A., Associate Professor of Mechanical Engineering, University of Calfornia, Berkeley, Calif. Harold Johnson, G. S. Emmerson.

SHULDINER, PAUL WILLIAM, Instructor in Civil Engineering, Ohio Northern University, Ada, Ohio. J. F. Klingenberger, L. H. Archer.

SIMPSON, HOWARD, Assistant Professor of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Mass. M. J. Holley, Jr., O. G. H. Dietz.

SMITH, RAYMOND VIRGIL, Assistant Professor of Mechanical Engineering, New Mexico College, State College, N. M. J. P. Morgan, A. M. Lukens.

STELSON, THOMAS EUGENE, Assistant Professor of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. F. T. Mavis, E. D'Appolonia.

TOOR, HERBERT L., Assistant Professor of Chemical Engineering, Carnegie Institute of Technology, Pittsburgh, Penna. Carl C. Monrad, Lawrence N. Canjar.

VELLINES, WESLEY ELMORE, JR., Chief Engineer, The C. & P. Telephone Company of Viriginia, Richmond, Va. R. A. Marr, Jr., John S. Jamison.

VOGEL, MILTON LEON, Instructor in Drawing and Descriptive Geometry, University of Wisconsin, Madison, Wis. R. R. Worsencroft, H. B. Doke.

VOGT, CARL J., Professor of Mechanical Engineering, University of California, Berkeley, Calif. G. S. Emmerson, H. N. Johnson.

WILTSE, JAMES CORNELIUS, JR., Instructor In Electrical Engineering, Johns Hopkins University, Baltimore, Maryland. Morris S. Ojalvo, John L. Artley.

ZUK, WILLIAM, Instructor in Structural Engineering, Cornell University, Ithaca, New York. John G. M. McEntyre, Arthur J. McNair.

307 new members elected this year

Review of Current Research Available . . .

You can now get your copy of the "Review of Current Research and Directory of Member Institutions," published by the ECRC. This is a complete directory of research projects in engineering colleges throughout the country. For a copy write to Professor Virgil Neilly at the Pennsylvania State University, State College, Pa., and enclose a check or money order in the amount of $2.50.

In The News

Interlingua

Scientists and engineers are giving the Western world something else to talk about—or with—a new language called Interlingua. In 1923, an international group of technical men, anxious to simplify the exchange of ideas and developments in science, organized to overcome the language barrier. The result was Interlingua, a union of five European tongues, with the peculiarities of each left out. The languages are English, French, Italian, Spanish, and Portuguese. A little German also is included. Twenty-five years of research by linguistics experts culminated in a book on Interlingua grammar, which is simplified in comparison to the European languages, and a 27,000-word Interlingua-English dictionary, which includes 17,000 technical terms. Currently being printed is a book using pictures to teach vocabulary entitled, "Interlingua a Prima Vista" (Interlingua at First Glance). An English-Interlingua vocabulary is about half finished.

The first publications in the new language were begun in 1952. "Spectroscopia Molecular" is one of them. It is published monthly by Dr. Forrest F. Cleveland, professor of physics at Illinois Institute of Technology, Chicago.

"Most scientists," he said, "may be surprised to find that they can read Interlingua with little reference to the dictionary or grammar." An example: "Energia es necessari pro toto que occurre in le mundo. In tempores passate le plus grande parte del energia applicate esseva fornite per le fortia muscular del homines e del animales domestic." The English equivalent is: "Energy is necesary for all that occurs in the world. In past times the greatest part of the applied energy was furnished by the muscular strength of men and domestic animals."

Although at present it is primarily a language to be read, it can be spoken, too. But the importance of Interlingua now is its usefulness in the fields of science and engineering.

Chief of the Interlingua division of Science Service is Dr. Alexander Gode, who holds a doctor's degree in Germanics from Columbia University and has taught modern languages at both Columbia and the University of Chicago. Dr. Gode was director of research for the International Auxiliary Language association. It was formed in 1923 by committees of the International Research council, by the American, British, French, and Italian associations for the advancement of science, the American Council of Learned Societies and other specialist groups. Dr. Gode presented the theory behind Interlingua in an article entitled, "The Case for Interlingua," in Scientific Monthly magazine, August, 1953.

It was summarized in four points:

1. The languages of the world cannot be reduced to one universal pattern. Instead, every language falls into one of many possible molds.

2. The internationalism of the twentieth century is propelled by ideological forces which have originated in the western world. These forces are understandable only in the molds of occidental speech and thought.

3. The languages of the west are so closely related to each other that it is sound to think of them as variations of one type language which is called Standard Average European.

4. To become international a language must have a force behind it to make it

spread: for example, Latin's influence spread through Europe with the Roman colonizing legions, Christianity, and the revival of classical Latin during the Renaissance. The motivating force of language in the twentieth century is science.

The concepts of science, Dr. Gode wrote, emerged in Europe, and the natural supranational language of science is Standard Average European. Interlingua, he concluded, is to date the most satisfactory system of language formed from Standard Average European.

Reserve this date . . . .

June 14-18, 1954

ANNUAL MEETING

UNIVERSITY OF ILLINOIS

URBANA, ILLINOIS

College Notes

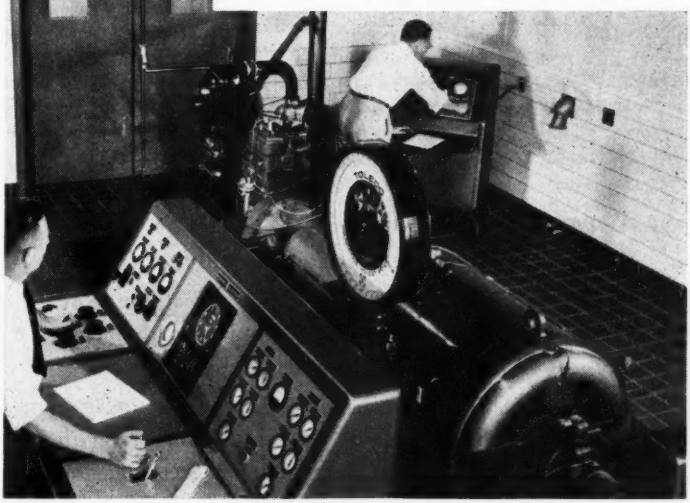
A joint five-year liberal arts-engineering curriculum for students at the University Heights center of **New York University** has been announced. The program will be available beginning with the fall 1954 semester. It enables students to obtain the degrees of bachelor of arts and bachelor of engineering in a particular branch of engineering. Students declare their intention of pursuing the combined curriculum after the freshman year. The first-year curriculum is a normal liberal arts program. Each successive year introduces a greater proportion of engineering courses until the fifth year when the program consists of engineering courses entirely. Degrees are awarded only after the fifth year, at which time the student has completed a major in engineering and two minors in liberal arts areas.

* * *

The **California Institute of Technology** is inaugurating a "3-2 plan" for the admission of men from certain selected liberal arts colleges as juniors at Caltech. Colleges with which arrangements for participation in the plan have been completed include Occidental College, Los Angeles; Pomona College, Claremont; and Whitman College, Walla Walla, Wash. Under the plan, a student may enroll in a cooperating college for an agreed-upon program for three years. On recommendation of the college he will then be admitted to Caltech as a junior. When he satisfactorily completes two more years of work at Caltech—for a total of five years of study—he will receive simultaneously the bachelor of arts degree from the college and the bachelor of science degree from Caltech.

OPPORTUNITY

...in "full measure!"



American industry has the world's most extensive research and engineering facilities. At International Harvester, where we must depend upon the best of engineering talent to engineer our essential products, we have greatly enlarged and improved our research and engineering facilities in recent years.

TODAY, International Harvester Company has more research and engineering projects underway than ever before. Here indeed is opportunity in full measure for the engineering graduate!

We need mechanical, industrial, metallurgical, chemical, agricultural and electrical engineers. We need engineers for training programs, for product designing, for testing programs, for research and experimentation in nearly all IH divisions.

The engineer who comes to Harvester invests his education in a sound, well-managed, progressive and growing company. He becomes a key figure in helping to supply the machines that underwrite the production facilities of the nation's most vital industries.

If you are interested in a career in the engineering fields mentioned above, with a good, progressive company, then we suggest you write to F. D. MacDonald, Education and Personnel Department, International Harvester Company, 180 N. Michigan Avenue, Chicago 1, Illinois.

INTERNATIONAL HARVESTER Chicago 1, Illinois

Builders of farm equipment for easier, more profitable farming . . . trucks for better transport . . . industrial power for road-building and earth-moving . . . refrigeration for better preservation of food

Automation *and graduation*

Automation is a much used word these days.

Particularly in the engineering fraternity.

For not only do manufacturing processes become more and more automatic, with engineering effort replacing physical effort everywhere along the line.

But products become even more simple for the user to operate—whether they be General Motors cars with automatic transmissions, Safety Power Steering, and Power Brakes, or Frigidaire refrigerators with automatic Cycla-Matic Defrosting and other conveniences.

Yet—the less physical effort required to build a product and to operate it – the more mental effort that goes into its design and engineering.

That's why we link the word Automation with the older word, Graduation. For more than ever before, industry needs brilliant engineering graduates. As a leader in the development of "more and better things for more people," General Motors keeps a constant search for graduate engineers with the brains and the ambition to help solve the increasing intricate engineering problems of the age of automation.

GENERAL MOTORS CORPORATION

Personnel Staff, Detroit 2, Michigan

Will your students choose the most rewarding careers?

It's easy for a graduate engineer to find employment these days. All the offers look so attractive that it's difficult to distinguish a routine job from a long term *career opportunity*.

To select the latter, the wise graduate will consider these questions carefully:

What is the company's background and record of achievement? Does its employment record show plenty of men whose jobs are sound careers? Is it an *essential* industry, deeply rooted? Is there activity, diversification, long range planning and projects, with room for advancement and professional recognition?

Curtiss-Wright can answer all these questions affirmatively. The company has a distinguished record of success, and sound plans for the years ahead.

It is a permanent part of America's industrial and defense structure . . . a great center of engineering. It has a distinguished staff under which an engineer's talents can increase. While fundamentally a world leader in aeronautics, the company's many collateral activities are in wholly unrelated industries. It creates new materials, new products and processes—even consumer goods.

This requires engineering specialists of many types. When trained and qualified, a man can work in the field in which his training and preference will insure faster advancement. He may choose aerodynamics, electronics, machine design, stress analysis, metallurgy, mechanics. He may work on propellers, reciprocating engines, turboprops, turbojets, turbo compounds, flight simulators or flight duplicators, electronic control systems or radar systems and components.

He can live in one of the finest residential areas with seashore and mountain lakes nearby. He may continue post-graduate education at one of several leading technical colleges conveniently near.

Curtiss-Wright is a leader in precision products. It offers brilliant engineers a brilliant future.

CURTISS-WRIGHT
CORPORATION • WOOD-RIDGE, N. J.

Message for

Student Counselors

Allis-Chalmers Offers Your Graduates a Unique Opportunity

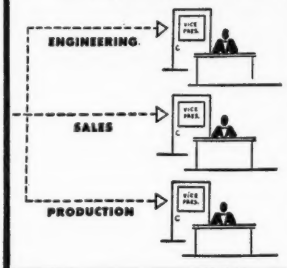
Your engineering graduate can get firsthand experience in nearly every industrial operation during his time on the Allis-Chalmers Graduate Training Course.

He can broaden his knowledge and viewpoint working on major equipment for electric power, mining, cement, agriculture, food and chemical processing, steel and many other industries. By the time he finishes the course, he is in the best possible position to make a success of his career in the industrial field of his choice.

Be sure that your engineering graduates are informed about the unique opportunity available at Allis-Chalmers.

The Right Job for the Right Man

. . . Unlimited Potential!



FACTS . . . About Allis-Chalmers Graduate Training Course

1. It's well established, having been started in 1904. A large percentage of the management group are graduates of the course.

2. The course offers a maximum of 24 months' training. Length and type of training is individually planned.

3. The graduate engineer may choose the kind of work he wants to do: design, engineering, research, production, sales, erection, service, etc.

4. He may choose the kind of power, processing, specialized equipment or industrial apparatus with which he will work, such as: steam or hydraulic turbo-generators, circuit breakers, unit substations, transformers, motors, control, pumps, kilns, coolers, rod and ball mills, crushers, vibrating screens, rectifiers, induction and dielectric heaters, grain mills, sifters, etc.

5. He will have individual attention and guidance in working out his training program.

6. The program has as its objective the right job for the right man. As he gets experience in different training locations, he can alter his course of training to match changing interests.

For information watch for the Allis-Chalmers representative visiting your campus, or call an Allis-Chalmers district office, or write Graduate Training Section, Allis-Chalmers, Milwaukee 1, Wis.

A-4025

ALLIS-CHALMERS

A MESSAGE TO COLLEGE ENGINEERING STUDENTS

from A. C. Montieth, Vice-President in Charge of Engineering and Research, Westinghouse Electric Corporation, *Queen's University, Kingston, Ontario, 1923*

The second most important decision in your life

Now, as you near graduation, you are about to make a decision—second in importance only to choosing your life's partner.

I'm talking, of course, about that all-important first job. Which company will it be? I wouldn't presume to answer that question for you. But I would like to emphasize the importance of this decision.

You have a lot at stake. The direction your career takes will most certainly be influenced by the company with which you cast your lot. May I offer a few personal suggestions?

Choose a company not for its bigness or smallness, but for how it will treat you as an individual. Choose it not only for its engineering activities alone but also for how it is set up to help its engineers develop themselves professionally. Choose your company with an eye on the opportunities ahead—and an eye on the future of the company itself. Above all, select a company that has a definite program to help you determine the work for which you are best fitted.

Only you can make this vital decision. Whatever it may be—good luck!

For information on career opportunities with Westinghouse, write: Educational Department, Westinghouse Electric Corp., East Pittsburgh, Pennsylvania

YOU CAN BE SURE...IF IT'S Westinghouse

This advertisement appears in College Engineering Magazines

Boeing offers graduates

ENGINEERING CAREERS *with a future*

When you counsel students, you want to guide them toward careers that offer opportunities for advancement, for varied experience and stability. Boeing fulfills *all* these requirements. For no industry approaches this one in offering young engineers such a wide range of experience, or such breadth of application—from pure research to production design, all going on simultaneously.

STABILITY

Boeing is in its 36th year. Its Engineering Division, which has grown practically continuously, now numbers over 6000, in contrast to a peak of 3500 at the height of World War II. Aircraft development is such an integral part of our national life that young engineers can enter it with full expectation of a rewarding, long-term career. While the Boeing Engineering Division is large, it is so organized that each engineer is an individual who stands out in proportion to his ability.

BREADTH OF EXPERIENCE

Boeing is constantly alert to new techniques and materials—and approaches them without limitations. Extensive sub-contracting and major procurement programs – directed and controlled by engineers – afford varied experience and broad contacts and relationships.

PRODUCTS

Boeing produces C-97 military transports, B-47 six-jet and B-52 eight-jet bombers. Through these fighter-fast jet bombers, Boeing has acquired an unmatched background in designing, building and flying multi-jet aircraft. It is the first American company to announce entry into the jet transport field. In addition, Boeing conducts a comprehensive guided missile program, research on nuclear-powered aircraft, and produces a revolutionary gas turbine.

RESEARCH

Boeing's research facilities are unsurpassed in the industry. They include America's only privately designed and owned trans-sonic wind tunnel, and acoustical, hydraulic, pneumatic, mechanical, electronics, vibration and physical research laboratories.

OPENINGS

Openings for graduates at Boeing lie in *all* branches of engineering, for work in aircraft designing, development, production, research and tooling. Also for servo-mechanism and electronics designers and analysts, and physicists and mathematicians. Boeing engineers work at engineering. The division is so organized that most drawings are made by draftsmen.

LOCATION

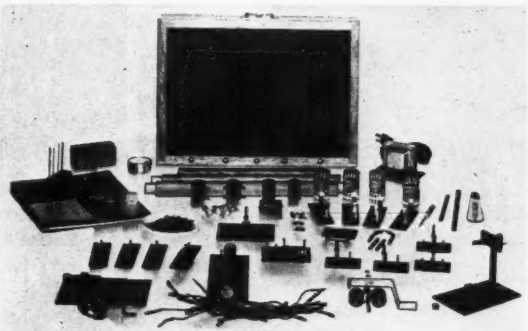
Boeing engineering activity is concentrated at Seattle in the Pacific Northwest and Wichita in the Midwest. In addition to skiing and mountain sports near Seattle, both communities offer fine fishing, hunting, golf, boating and other recreational opportunities. Both are fresh, modern cities with fine residential and shopping districts, and schools of higher learning where engineers can study for advanced degrees.

INFORMATION

If you or any of your students would like additional information about engineering careers at Boeing, write to John C. Sanders, Staff Engineer-Personnel, Boeing Airplane Company, Seattle 14, Washington.

FOR TEACHING ELEMENTARY ELECTRICITY

Use The New CROW Beginner's Experimental Kit

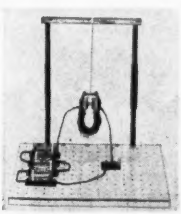


- **SAFE**—Uses only 6 Volt D.C. and A.C.; same as flashlight—no possibility of shock.
- **COMPLETE**—Comes with 240 page text-manual containing 319 illustrations.
- **COMPREHENSIVE**—Covers magnetism, circuits, transformers, electrical devices, motors, and controls.
- **INEXPENSIVE**—*Every* one can now afford instruction in electricity!
- **FOR BEGINNERS**—Manual written for elementary students; no mathematics—profusely illustrated.
- **STUDENTS 'LEARN BY DOING'**—Construct their own operating assemblies.
- **PORTABLE**—Can be carried from room to room or issued to students for home study use.

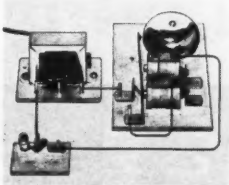
Experiments and assemblies cover:

Permanent Magnetism . . . Electro-Magnetism . . . Circuitry, switches, fuses . . . Induction and transformers . . . D.C. and A.C. electric motors and controls . . . Bells . . . Buzzers . . . Thermostats . . . Relays

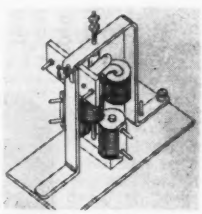
- **PRICE**—Complete with manual, transformer and portable case.....**$47.50**



Electro-Magnet Experiment



Bell Assembly and Circuit



Sketch of AC Motor Assembly

WRITE FOR ILLUSTRATED BULLETIN

UNIVERSAL SCIENTIFIC COMPANY

INCORPORATED

BOX 336H **VINCENNES, INDIANA**

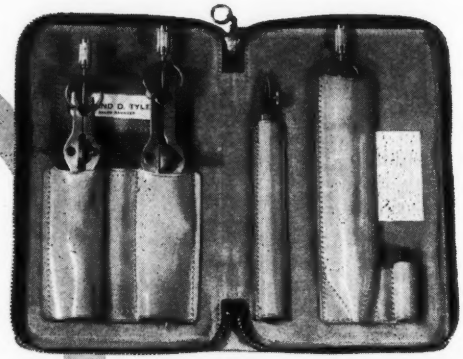
THERE'S A VEMCO DRAWING SET FOR *every* NEED

VEMCO sets are available in standard and special arrangements—in four types of cases—and in these two grades:

VEMCO hand finished stainless steel Blue Dot instruments are supreme in accuracy, durability and finish. The professional or the student engineer will take pride in these instruments.

VEMCO chrome plated steel Red Dot instruments are outstanding in quality, yet popularly priced. These instruments are having favorable acceptance in many of the leading universities.

Write for a free copy of "Historical Note on Drawing Instruments."



Here is the striking new pocket size (4¼"x7⅛") VEMCO saddle leather case with zipper closure. This set No. H-171-L includes 6½" Bow Compass, 4½" Bow Compass, 6½" Friction Divider, 5½" Slip Handle Ruling Pen, and Tube for extra leads and points.

Set No. A-171-V

V & E MANUFACTURING CO. • PASADENA 20, CALIF.

Audio, H

Each around Only o separate keep th pensive larger e This is viding minimu

These into one variety

1954

V & E MANUFACTURING CO. • PASADENA 20, CALIF.

GR UNIT INSTRUMENTS

Rugged, Dependable, Interchangeable, and Inexpensive

Power Supplies • Amplifiers
Null Detectors • Pulse Generators
Audio, High-Frequency, Crystal Oscillators

Each G-R Unit Instrument is built around a fundamental electronic circuit. Only one distinct function is packaged separately in each compact unit. To keep these instruments simple and inexpensive, refinements incorporated in larger equipment are usually excluded. This is the G-R UNIT concept for providing laboratory-quality equipment at minimum cost.

These instruments plug conveniently into one another making possible a wide variety of assemblies and setups. An example illustrates the System's versatility. . . .

One of the Unit Oscillators, plus a power supply serves as an unmodulated, general-purpose laboratory power source. Add a fixed-frequency Unit Oscillator, and you have a modulated power source. Add an attenuator, a crystal rectifier and meter and you have a standard-signal generator. Substitute a different Unit Oscillator, and the system covers a new frequency range. The addition of a Unit Amplifier gives more power.

There is no end to the assemblies and combinations possible . . . particularly when one considers the variety of Unit Instruments now available. Write for more information.

500 Kc to 50 Mc GR Unit Oscillator for College Laboratory or Research Project

This Unit Oscillator . . . another of the popular G-R Unit Instruments . . . covers a 100:1 frequency span by simultaneously varying both capacitance and inductance of the Hartley-type tuned circuit. It features:

★ Wide frequency range ★ Accurate calibration — frequency-increment settings to 0.002 of each main dial division ★ As much as 2 watts from 0.5 to 5 Mc — 200 mw from 5 to 50 Mc ★ Terminals for amplitude modulation — 45 v, audio gives 25% modulation with less than 3% envelope distortion ★ With the accessory Type 1000-P6 Crystal Diode Modulator, this oscillator may be video modulated above 10 Mc with negligible incidental f-m ★ Careful shielding throughout; power input leads filtered ★ Dimensions, 7 x 8 x 12 inches ★ Net Weight 11½ lbs.

Type 1211-A Unit Oscillator . . . $295.00

Since 1915 — GR

Manufacturers of Electronic Apparatus for Science and Industry

GENERAL RADIO Company
275 Massachusetts Avenue, Cambridge 39, Massachusetts, U.S.A.

Admittance Meters ☆ Amplifiers ☆ Coaxial Elements ☆ Distortion Meters ☆ Frequency Measuring Apparatus ☆ Frequency Standards ☆ Impedance Bridges ☆ Light Meters ☆ Megohmmeters ☆ Modulation Meters ☆ Polariscopes ☆ Precision Capacitors ☆ Oscillators ☆ U-H-F Measuring Equipment ☆ Parts & Accessories ☆ Signal Generators ☆ Wave Analyzers ☆ Variacs ☆ TV & Broadcast Monitors ☆ Pulse Generators ☆ R-L-C Decades ☆ R-L-C Standards ☆ Unit Instruments ☆ Sound & Vibration Meters ☆ Stroboscopes ☆ Null Detectors ☆ Motor Controls ☆ Wave Filters ☆ V-T Voltmeters

A COMPLETE PRINTING SERVICE . . .

GOOD PRINTING does not just happen; it is the result of careful planning. The knowledge of our craftsmen, who for many years have been handling details of composition, printing and binding, is at your disposal. For seventy-five years we have been printers of scientific and technical journals, books, theses, dissertations and works in foreign languages. Consult us about your next job.

PRINTERS OF THE
JOURNAL OF ENGINEERING EDUCATION

LANCASTER PRESS, Inc.

PRINTERS · BINDERS · ELECTROTYPERS

ESTABLISHED 1877 LANCASTER, PA.

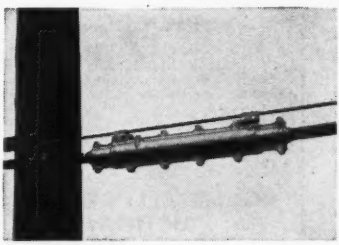
BOLTING VOICES TOGETHER

Adjusting casing over splice in polyethylene cable. Edges and ends are sealed with a new Butyl rubber compound that won't harden, dry out or lose adhesion even in extreme heat or cold.

More than ever, light, flexible polyethylene sheathed cable developed by Bell Telephone Laboratories is providing speedy answers to the demand for more telephone service.

But at thousands of splices, the sheath must be thoroughly sealed against moisture. Laboratories engineers developed a protective casing which is quickly and simply bolted in place. The edges and ends of the casing are *permanently* sealed with a new compound developed by Laboratories rubber chemists.

Now, economical polyethylene cable can be installed much faster and at lower cost. Here is another example of how Bell Laboratories continually finds ways to keep telephone service high in quality, while the cost stays low.



CLOSED CASING IN PLACE

BELL TELEPHONE LABORATORIES

EXPLORING AND INVENTING, DEVISING AND PERFECTING, FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE.

Which of These 8 Reinhold Books Do You Want to Examine On Approval?

The selection of technical books for engineering courses always calls for a certain amount of deliberation. That's why Reinhold has always made it a policy to offer these books to college professors and instructors for 30 days' free examination. Check over the following titles and decide which books would be of interest to you or your students. Should you adopt any for text use, the charges on those books will be cancelled. Otherwise simply return the books or send payment at list price less special educational discount.

INDUCTION AND DIELECTRIC HEATING

By J. WESLEY CABLE

Here is a well-organized treatment of the latest uses and applications of high-frequency heating in industry. Contains sufficient theory to enable the student to understand fully the basic phenomena applicable to both methods.

1954 620 pages Illustrated $12.50

ORGANIC PROTECTIVE COATINGS

Edited by WILLIAM VON FISCHER and EDWARD G. BOBALEK

Emphasizing the problems of formulation, specification and application of organic coatings, this much-needed new book includes data on the development of anti-corrosive and luminescent pigments, aminoplast resins, hot spray lacquers, emulsion and latex paints; use of organic coatings on electrical insulation; silicone resins and heat-resistant paints.

1953 400 pages $7.50

CHEMICAL ENGINEERING TECHNIQUES

By B. E. LAUER and RUSSELL F. HECKMAN

A unique textbook designed for the introductory course in chemical engineering; covers a vast region of practical subjects with which the students should be familiar before entering upon the study of unit processes.

1952 450 pages $6.00

METALLURGICAL DICTIONARY

By J. G. HENDERSON

This amazingly complete reference work contains over 5,000 easy-to-understand definitions of all the most common terms used in metallurgy. Indispensable to students, teachers and all others interested in metal fields.

1953 416 pages $8.50

INDUSTRIAL WASTES

Their Treatment and Disposal

ACS Monograph No. 118

Edited by WILLEM RUDOLFS

Written by a group of experts with long experience in the treatment of industrial wastes, this much-needed monograph offers a thorough, completely up to date study of the disposal problems of many industries.

1953 450 pages $9.50

CHEMICAL PROCESS MACHINERY (2nd Edition)

By E. RAYMOND RIEGEL

This new, greatly enlarged edition brings the material abreast of latest developments in the equipment of the chemical and process industries. Scores of new diagrams, photographs and tables.

1953 740 pages $12.50

TOOL ENGINEERS' DATA BOOK

By GERHARD J. GRUEN

This valuable new book brings you all of the tables, formulas and specifications needed by the practicing tool engineer and designer. Includes much recent information on special alloys, heat treatment, and spot identification of metals, alloys and plastics.

1953 220 pages $5.50

TEXTILE FIBERS, YARNS AND FABRICS

A Comparative Survey of Their Behavior with Special Reference to Wool

By ERNEST R. KASWELL

Based directly on the research results of over 400 investigators, this eagerly-awaited book is the first to evaluate the engineering, physical and chemical behavior of textile fibers, yarns and fabrics, both natural and synthetic.

1953 550 pages $11.00

Send for your copies today!

REINHOLD PUBLISHING CORP.

330 West 42nd Street Dept. M-619 New York 36, N. Y.

h 1954

KS

?

for
ade
for
ide
you
ed.
ess

long
trial
ffers
y of
ries.
9.50

n)

ings
ents
and
ams,
2.50

f the
eded
ner.
ecial
fica-
5.50

IS

vior

s of
ited
neer-
r of
both
1.00

. Y.

VAN NOSTRAND FOR COLLEGE TEXTS

Outstanding Publications

MICROWAVE THEORY AND TECHNIQUES

By REICH, ORDUNG, KRAUSS and SKALNIK

This new comprehensive text emphasizes the theory and applications of microwave tubes and circuits, and covers most of the recent advances in this field. Prepared for advanced courses, it will also be welcomed by practicing engineers as a reference book. *901 pages 1953 $10.00*

3RD EDITION — MORSE'S

POWER PLANT ENGINEERING

By FREDERICK T. MORSE

This THIRD EDITION maintains the same successful approach which distinguished the first two editions. Being completely revised and brought up to date, it is essentially a NEW BOOK. Better balance achieved; many subjects expanded; operating engineers' problems amplified. *687 pages 1953 $8.75*

FUNDAMENTALS OF STRUCTURAL ANALYSIS

By JAKKULA and STEPHENSON

Designed for the first course in structural engineering, this excellent text introduces the basic elements, fundamental principles, and elementary procedures involved in the stress analysis of statically determined structures. *288 pages 1953 $4.50*

2ND EDITION

ENGINEERING MECHANICS

By COX and PLUMTREE

This NEW EDITION, now under the co-authorship of two educators, is designed for students majoring in all branches of engineering. It differs from the first edition in three distinct ways: (1) there has been a substantial rearrangement of the subject matter, (2) the coverage of the material has been enlarged in many instances, and (3) the number of problems has been increased materially. A PROBLEMS SOLUTION BOOK will be available. *Ready in April*

Send for copies on approval

D. VAN NOSTRAND COMPANY, INC.
Publishers Since 1848
250 FOURTH AVE.
NEW YORK, N.Y.

New **McGRAW-HILL** *Books*

INDUSTRIAL STOICHIOMETRY. New second edition

By WARREN K. LEWIS, Massachusetts Institute of Technology, ARTHUR H. RADASCH, The Cooper Union, and H. CLAY LEWIS, Georgia Institute of Technology. *McGraw-Hill Series in Chemical Engineering.* In press

The long-awaited revision of this widely known chemical engineering book is designed to develop skill in the art of applying computation methods in the analysis of processing operations and in the analysis and solution of processing difficulties. The book has been completely revised but the authors have retained the case method of illustrating techniques of computation. New materials cover equilibrium and driving forces, nitrogen compounds, alkalies, and ceramic calculations. Only a prior knowledge of general chemistry is required for understanding the book.

ASME HANDBOOK: Part I, Metals Properties

Sponsored by the Metals Engineering Handbook Board, American Society of Mechanical Engineers. Edited by SAMUEL HOYT, Metallurgical Consultant, Batelle Memorial Institute. 454 pages, $11.00

This is the first of a four-volume handbook for designers, draftsmen, students, and engineers in the product design and manufacturing and production engineering groups. Explanatory treatises and reference data are combined. *Metals Properties* tabulates data on strength, hardness, machinability, electrical conductivity, thermal conductivity, and other properties of more than 500 metals.

ESSENTIALS OF INDUSTRIAL MANAGEMENT

By LAWRENCE L. BETHEL, New Haven College; FRANKLIN S. ATWATER, The Fafnir Bearing Company; GEORGE H. E. SMITH, Lawyer and Economist; and HARVEY A. STACKMAN, JR., President, Executive Development Council. *McGraw-Hill Industrial Organization and Management Series.* In press

Coordination as the goal for good management is the major point of emphasis in this comprehensive, yet brief, treatment of the field of industrial management. The technical aspects of the subject and the various approaches to managerial problems are treated with equal thoroughness. The balanced treatment of all phases of industrial management, the abundance of illustrations, and the thorough explanation of fundamental principles make this book, like the author's *Industrial Organization and Management,* a truly distinctive volume.

DESIGN OF CONCRETE STRUCTURES. New fifth edition

By L. C. URQUHART, Porter-Urquhart, Consulting Engineers and C. E. O'ROURKE. Revised by COLONEL URQUHART, and GEORGE WINTER, Cornell University. In press

Thoroughly revised to account for the many new developments in concrete technology and design method of the past two decades, this new edition prepared by Urquhart and Winter has greater emphasis on basic structural performance, fundamental mechanics and physical explanation while retaining the basic method of presentation and general arrangement of material which have made this book useful as a text for students.

Send for copies on approval

McGRAW-HILL BOOK COMPANY, Inc.

330 West 42nd Street **New York 36, N. Y.**